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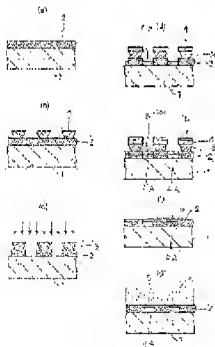
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(54) SURFACE ACOUSTIC WAVE APPARATUS AND MANUFACTURING METHOD THEREFOR



(57) Abstract:

PROBLEM TO BE SOLVED: To provide a manufacturing method for a surface acoustic wave (SAW) apparatus in which deterioration of characteristics caused by unwanted ripple is suppressed by sufficiently enlarging the reflection coefficient of an IDT in the SAW apparatus equipped with a structure formed with an insulating layer to cover an IDT electrode.

SOLUTION: In the SAW apparatus, a first insulating layer 2 is formed on the entire surface of a piezoelectric LiTaO₃ substrate. By using a resist pattern 3 used for forming the IDT electrode, the first insulating layer 2 in which the IDT electrode is to be formed is removed. An electrode film made of a metal having a density higher than Al or of an alloy primarily including such a metal is disposed in the area in which the first insulating layer is removed so as to form an IDT electrode 4A. The resist pattern remaining on the first insulating layer is removed. A second insulating layer 6 is formed to cover the first insulating layer 2 and the IDT electrode 4A.

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CLAIMS

[Claim(s)]

[Claim 1]

The piezoelectric substrate with which an electromechanical coupling coefficient consists of 15% or more of LiTaO₃ or LiNbO₃,
At least one electrode which is formed on said piezoelectric substrate and consists of cascade screens which consist of an alloy which uses the large metal or this metal of a consistency as a principal component, and other metals rather than the alloy which uses the large metal or this metal of a consistency as a principal component rather than aluminum, or aluminum,
The 1st insulating material layer which was in said electrode, abbreviation, etc. by carrying out in the remaining fields except the field in which said at least one electrode is formed, and was formed in thickness,
It has the 2nd insulating material layer formed so that said electrode and the 1st insulating material layer might be covered,
Surface acoustic wave equipment whose consistency of said electrode is 1.5 or more times of said 1st insulating material layer.

[Claim 2]

Piezoelectric substrate,
At least one electrode formed on said piezoelectric substrate,
The protection metal membrane which consists of the metal or alloy which excelled the metal or alloy which is formed on said electrode and constitutes an electrode in corrosion resistance,
The 1st insulating material layer formed so that the thickness of the sum total of said electrode and protection metal membrane, abbreviation, etc. might be by carrying out in the remaining fields except the field in which said at least one electrode is formed and it might have thickness,
Surface acoustic wave equipment equipped with the 2nd insulating material layer formed so that said protection metal membrane and the 1st insulating material layer might be covered.

[Claim 3]

Surface acoustic wave equipment according to claim 2 whose mean density of the whole laminated structure of said electrode and a protection metal membrane is 1.5 or more times of the consistency of said 1st insulating material layer.

[Claim 4]

Surface acoustic wave equipment according to claim 1 to 3 with which the

said 1st and 2nd insulating material layer is formed of SiO₂.

[Claim 5]

Surface acoustic wave equipment according to claim 1 to 4 which is surface acoustic wave equipment using reflection of a surface acoustic wave.

[Claim 6]

Said piezoelectric substrate is LiTaO₃ substrate of an Eulerian angle (0°-104 degrees - 140 degrees, 0°-140 degrees). When wavelength of Hs and a surface acoustic wave is set to λ , the sum total thickness of SiO₂ film which the said 1st and 2nd insulating material layer consists of SiO₂, and constitutes the 1st and 2nd insulating material layer Surface acoustic wave equipment according to claim 1 to 5 made into the value with which standardization thickness H/λ of an electrode fills the following formula (1) when Hs/λ is made into the range of 0.03-0.45 and sets wavelength of H and a surface acoustic wave to λ for the thickness of said electrode.

$0.005 \leq H/\lambda \leq 0.00025\rho^2 - 0.01056\rho + 0.16473$ (however, ρ mean density of an electrode) -- Formula (1)

[Claim 7]

Said piezoelectric substrate is LiTaO₃ substrate of an Eulerian angle (0°-115 degrees - 148 degrees, 0°-148 degrees), the said 1st and 2nd insulating material layer consists of SiO₂ film, and standardization thickness Hs/λ of the sum total of SiO₂ film is in the range of 0.03-0.45,

Surface acoustic wave equipment given in either of claims 1, 4-6 which has standardization thickness H/λ in the range of 0.013-0.032 when a consistency 15000 - 23000 kg/m³ and Young's modulus 0.5×10^{11} - 1.0×10^{11} N/m², or transverse-wave acoustic velocity is the metal which is 1000 - 2000 m/s and a metal with a larger consistency than said aluminum sets wavelength of H and a surface acoustic wave to λ for the thickness of said electrode.

[Claim 8]

Surface acoustic wave equipment according to claim 7 said whose metal is Au.

[Claim 9]

Surface acoustic wave equipment according to claim 7 or 8 which has the Eulerian angle of said LiTaO₃ substrate in the range of (0°-132 degrees - 148 degrees, 0°-148 degrees).

[Claim 10]

Surface acoustic wave equipment according to claim 7 or 8 which has θ of the Eulerian angle of said LiTaO₃ substrate in the range of 115

degrees or more and less than 132 degrees.

[Claim 11]

Surface acoustic wave equipment according to claim 7 or 8 whose standardization thickness H_s/λ of SiO_2 which constitutes standardization thickness H/λ and the 1st and 2nd insulating material layer of the Eulerian angle ($0^{\circ} \pm 3^{\circ}$, θ , $0^{\circ} \pm 3^{\circ}$) of said LiTaO_3 substrate and said electrode is either of the combination shown in the following table 1.

[Table 1]

オイ-角 ($0 \pm 3^{\circ}$, θ , $0 \pm 3^{\circ}$) の θ	Au 膜厚	SiO_2 膜厚
$120.0^{\circ} \leq \theta < 123.0^{\circ}$	0.013~0.018	0.15~0.45
$123.0^{\circ} \leq \theta < 124.5^{\circ}$	0.013~0.022	0.10~0.40
$124.5^{\circ} \leq \theta < 125.5^{\circ}$	0.013~0.025	0.07~0.40
$125.5^{\circ} \leq \theta < 127.5^{\circ}$	0.013~0.025	0.06~0.40
$127.5^{\circ} \leq \theta < 129.0^{\circ}$	0.013~0.028	0.04~0.40
$129.0^{\circ} \leq \theta < 130.0^{\circ}$	0.017~0.030	0.03~0.42
$130.0^{\circ} \leq \theta < 131.5^{\circ}$	0.017~0.030	0.03~0.42
$131.5^{\circ} \leq \theta < 133.0^{\circ}$	0.018~0.028	0.05~0.33
$133.0^{\circ} \leq \theta < 135.0^{\circ}$	0.018~0.030	0.05~0.30
$135.0^{\circ} \leq \theta \leq 137.0^{\circ}$	0.019~0.032	0.05~0.25
$137.0^{\circ} \leq \theta \leq 140.0^{\circ}$	0.019~0.032	0.05~0.25

[Claim 12]

Surface acoustic wave equipment according to claim 7 or 8 whose standardization thickness H_s/λ of SiO_2 which constitutes standardization thickness H/λ and the 1st and 2nd insulating material layer of the Eulerian angle ($0^{\circ} \pm 3^{\circ}$, θ , $0^{\circ} \pm 3^{\circ}$) of said LiTaO_3 substrate and said electrode is either of the combination shown in the following table 2.

[Table 2]

Ag膜厚 H/λ : 0.01~0.08のとき

SiO ₂ 膜厚	LiTaO ₃ のオイラー角
0.15~0.18	0±3, 117~137, 0±3
0.18~0.23	0±3, 117~136, 0±3
0.23~0.28	0±3, 115~135, 0±3
0.28~0.33	0±3, 113~133, 0±3
0.33~0.38	0±3, 113~135, 0±3
0.38~0.40	0±3, 113~132, 0±3

[Claim 16]

Surface acoustic wave equipment according to claim 13 or 14
standardization thickness H_s/λ of the sum total of said SiO₂ film
and whose Eulerian angle of LiTaO₃ substrate standardization thickness
 H/λ of said electrode is 0.02-0.06, and are either of the
combination shown in the following table 4.

[Table 4]

Ag膜厚 H/λ : 0.02~0.06のとき

SiO ₂ 膜厚	LiTaO ₃ のオイラー角
0.15~0.18	0±3, 120~133, 0±3
0.18~0.23	0±3, 120~137, 0±3
0.23~0.28	0±3, 120~135, 0±3
0.28~0.33	0±3, 118~135, 0±3
0.33~0.38	0±3, 115~133, 0±3
0.38~0.40	0±3, 113~130, 0±3

[Claim 17]

Surface acoustic wave equipment according to claim 13 or 14
standardization thickness H_s/λ of the sum total of said SiO₂ film
and whose Eulerian angle of LiTaO₃ substrate standardization thickness
 H/λ of said electrode is 0.03-0.05, and are either of the
combination shown in the following table 5.

[Table 5]

Ag膜厚 H/λ : 0.03 ~ 0.05 のとき

SiO ₂ 膜厚	LiTaO ₃ のオイラー角
0.15 ~ 0.18	0 ± 3, 122 ~ 142, 0 ± 3
0.18 ~ 0.23	0 ± 3, 120 ~ 140, 0 ± 3
0.23 ~ 0.28	0 ± 3, 117 ~ 138, 0 ± 3
0.28 ~ 0.33	0 ± 3, 116 ~ 136, 0 ± 3
0.33 ~ 0.38	0 ± 3, 114 ~ 135, 0 ± 3
0.38 ~ 0.40	0 ± 3, 113 ~ 130, 0 ± 3

[Claim 18]

Said piezoelectric substrate is LiTaO₃ substrate of an Eulerian angle (0° ± 3 degrees, 113 degrees - 137 degrees, 0° ± 3 degrees), said 1st and 2nd insulating material layer consists of SiO₂ film, and standardization thickness H_s/λ of the sum total of SiO₂ film is in the range of 0.10-0.40,

Surface acoustic wave equipment given in either of claims 1, 4-6 which has standardization thickness H/λ in the range of 0.01-0.08 when a consistency 5000 - 15000 kg/m³ and Young's modulus 1.0×10^{11} - 2.05×10^{11} N/m², or transverse-wave acoustic velocity is the metal which is 2000 - 2800 m/s and a metal with a larger consistency than said aluminum sets wavelength of H and a surface acoustic wave to λ for the thickness of said electrode.

[Claim 19]

Surface acoustic wave equipment according to claim 18 said whose metal is Cu.

[Claim 20]

Surface acoustic wave equipment according to claim 18 or 19 whose standardization thickness H_s/λ of the Eulerian angle of said LiTaO₃ substrate and said sum total of SiO₂ is either of the combination shown in the following table 6.

[Table 6]

SiO ₂ 膜厚	LiTaO ₃ のオイラー角
0.15~0.18	(0±3, 117~137, 0±3)
0.18~0.23	(0±3, 117~136, 0±3)
0.23~0.28	(0±3, 115~135, 0±3)
0.28~0.33	(0±3, 113~133, 0±3)
0.33~0.38	(0±3, 113~135, 0±3)
0.38~0.4	(0±3, 113~132, 0±3)

[Claim 21]

Surface acoustic wave equipment according to claim 18 or 19 characterized by theta of said Eulerian angle (0 ± 3 degrees, theta, 0 ± 3 degrees) being in the range of the following formula (2).

$\theta_{\min} - 2 \text{ degree} < \theta \leq \theta_{\min} + 2 \text{ degree}$ -- Formula (2)

However, among a formula (2), θ_{\min} is a value expressed with following formula A-E, respectively, when standardization thickness H/λ of IDT is the range of following (a) - (e).

(a) At the time of $0 < H/\lambda \leq 0.01$

$\theta_{\min} = -139.713xHs^3 + 43.07132xHs^2 - 20.568011xHs + 125.8314$ -- At the time of formula A(b) $0.01 < H/\lambda \leq 0.03$

$\theta_{\min} = -139.660xHs^3 + 46.02985xHs^2 - 21.141500xHs + 127.4181$ -- At the time of formula B(c) $0.03 < H/\lambda \leq 0.05$

$\theta_{\min} = -139.607xHs^3 + 48.98838xHs^2 - 21.714900xHs + 129.0048$ -- At the time of formula C(d) $0.05 < H/\lambda \leq 0.07$

$\theta_{\min} = -112.068xHs^3 + 39.60355xHs^2 - 21.186000xHs + 129.9397$ -- At the time of formula D(e) $0.07 < H/\lambda \leq 0.09$

$\theta_{\min} = -126.954xHs^3 + 67.40488xHs^2 - 29.432000xHs + 131.5686$ -- Formula E

[Claim 22]

Surface acoustic wave equipment according to claim 18 or 19 standardization thickness Hs/λ of the sum total of said SiO₂ film and whose Eulerian angle of LiTaO₃ substrate are either of the combination shown in the following table 7.

[Table 7]

SiO ₂ 膜厚	LiTaO ₃ のオイラー角
0.15~0.18	(0±3, 117~125, 0±3)
0.18~0.23	(0±3, 117~125, 0±3)
0.23~0.28	(0±3, 115~125, 0±3)
0.28~0.33	(0±3, 113~125, 0±3)
0.33~0.38	(0±3, 113~125, 0±3)
0.38~0.40	(0±3, 113~125, 0±3)

[Claim 23]

Said piezoelectric substrate is LiTaO₃ substrate of an Eulerian angle (0°±3 degrees, 112 degrees - 138 degrees, 0°±3 degrees), said 1st and 2nd insulating material layer consists of SiO₂ film, and standardization thickness H/λ of the sum total of SiO₂ film is in the range of 0.10-0.40,

Surface acoustic wave equipment given in either of claims 1, 4-6 which has standardization thickness H/λ in the range of 0.025-0.06 when a consistency 15000 - 23000 kg/m³ and Young's modulus 2.0x10¹¹ - 4.5x10¹¹ N/m², or transverse-wave acoustic velocity is the metal which is 2800 - 3500 m/s and a metal with a larger consistency than said aluminum sets wavelength of H and a surface acoustic wave to λ for the thickness of said electrode.

[Claim 24]

Surface acoustic wave equipment according to claim 23 said whose metal is a tungsten.

[Claim 25]

Surface acoustic wave equipment according to claim 23 or 24 which has said standardization thickness H/λ of IDT in the range of 0.012-0.053.

[Claim 26]

Surface acoustic wave equipment according to claim 25 which has said standardization thickness H/λ of IDT in the range of 0.015-0.042.

[Claim 27]

Surface acoustic wave equipment according to claim 23 to 25 said whose LiTaO₃ substrate is LiTaO₃ substrate of an Eulerian angle (0°±3 degrees, 115 degrees - 135 degrees, 0°±3 degrees).

[Claim 28]

Surface acoustic wave equipment according to claim 23 or 24 standardization thickness H/λ of said electrode is 0.012-0.053, and

is [equipment] either of the combination which standardization thickness H/λ of the sum total of said SiO₂ film and the Eulerian angle of LiTaO₃ substrate show in the following table 8.

[Table 8]

電極の $H/\lambda = 0.012 \sim 0.053$ のとき

SiO ₂ の規格化膜厚	LiTaO ₃ のオイラ-角
0.1~0.15	(0±3, 114.2~138, 0±3)
0.15~0.2	(0±3, 113~137.8, 0±3)
0.2~0.3	(0±3, 113~137.5, 0±3)
0.3~0.35	(0±3, 112.7~137, 0±3)
0.35~0.4	(0±3, 112.5~136, 0±3)

[Claim 29]

Surface acoustic wave equipment according to claim 23 or 24 standardization thickness H/λ of said electrode is 0.015-0.042, and is [equipment] either of the combination which standardization thickness H/λ of the sum total of said SiO₂ film and the Eulerian angle of LiTaO₃ substrate show in the following table 9.

[Table 9]

電極の $H/\lambda = 0.015 \sim 0.042$ のとき

SiO ₂ の規格化膜厚	LiTaO ₃ のオイラ-角
0.1~0.15	(0±3, 114.3~138, 0±3)
0.15~0.2	(0±3, 113~137.5, 0±3)
0.2~0.3	(0±3, 112.5~137, 0±3)
0.3~0.35	(0±3, 112.2~136.5, 0±3)
0.35~0.4	(0±3, 112~135.3, 0±3)

[Claim 30]

Said piezoelectric substrate is LiTaO₃ substrate of an Eulerian angle (0° degrees, 104 degrees - 148 degrees, 0° degrees), said 1st and 2nd insulating material layer consists of SiO₂ film, and standardization thickness H/λ of the sum total of SiO₂ film is in the range of 0.10-0.40,

Surface acoustic wave equipment given in either of claims 1, 4-6 which has standardization thickness H/λ in the range of 0.004-0.055 when

a consistency 15000 - 23000 kg/m³ and Young's modulus 1.0×10^{11} - 2.0×10^{11} N/m², or transverse-wave acoustic velocity is the metal which is 2000 - 2800 m/s and a metal with a larger consistency than said aluminum sets wavelength of H and a surface acoustic wave to λ for the thickness of said electrode.

[Claim 31]

Surface acoustic wave equipment according to claim 30 said whose metal is a tantalum.

[Claim 32]

Surface acoustic wave equipment according to claim 30 or 31 which has standardization thickness H/λ of said electrode in the range of 0.01-0.55.

[Claim 33]

Surface acoustic wave equipment according to claim 30 or 31 which has standardization thickness H/λ of said electrode in the range of 0.016-0.045.

[Claim 34]

Surface acoustic wave equipment according to claim 30 to 32 said whose piezoelectric substrate is LiTaO₃ substrate of an Eulerian angle (0 ± 3 degrees, 111 degrees - 143 degrees, 0 ± 3 degrees).

[Claim 35]

Surface acoustic wave equipment according to claim 30 or 31 standardization thickness H/λ of said electrode is 0.01-0.055, and is [equipment] either of the combination which standardization thickness H_s/λ of the sum total of said SiO₂ film and the Eulerian angle of LiTaO₃ substrate show in the following table 10.

[Table 10]

電極の $H/\lambda = 0.01 \sim 0.055$ のとき

SiO ₂ の規格化膜厚	LiTaO ₃ のオイラ-角
0.1 ~ 0.15	($0 \pm 3, 110.5 \sim 148, 0 \pm 3$)
0.15 ~ 0.2	($0 \pm 3, 108 \sim 147.5, 0 \pm 3$)
0.2 ~ 0.3	($0 \pm 3, 105 \sim 148, 0 \pm 3$)
0.3 ~ 0.35	($0 \pm 3, 104.5 \sim 148, 0 \pm 3$)
0.35 ~ 0.4	($0 \pm 3, 104 \sim 145, 0 \pm 3$)

[Claim 36]

Surface acoustic wave equipment according to claim 30 or 31 standardization thickness H_s/λ of the sum total of said SiO₂ film

and whose Eulerian angle of LiTaO₃ substrate standardization thickness H/lambda of said electrode is 0.016-0.045, and are either of the combination shown in the following table 11.

[Table 11]

電極の $H/\lambda = 0.016 \sim 0.045$ のとき

SiO ₂ の規格化膜厚	LiTaO ₃ のオイラ-角
0.1~0.15	(0±3, 113~144, 0±3)
0.15~0.2	(0±3, 111~144, 0±3)
0.2~0.3	(0±3, 108~144, 0±3)
0.3~0.35	(0±3, 107.5~143, 0±3)
0.35~0.4	(0±3, 107~140.5, 0±3)

[Claim 37]

Said piezoelectric substrate is LiTaO₃ substrate of an Eulerian angle (0° degrees, 90 degrees - 169 degrees, 0° degrees), said 1st and 2nd insulating material layer consists of SiO₂ film, and standardization thickness Hs/lambda of the sum total of SiO₂ film is in the range of 0.10-0.40,

Surface acoustic wave equipment given in either of claims 1, 4-6 which has standardization thickness H/lambda in the range of 0.005-0.054 when a consistency 15000 - 23000 kg/m³ and Young's modulus 1.0×10^{11} - 2.0×10^{11} N/m², or transverse-wave acoustic velocity is the metal of 1000 - 2000 m/s and a metal with a larger consistency than said aluminum sets wavelength of H and a surface acoustic wave to lambda for the thickness of said electrode.

[Claim 38]

Surface acoustic wave equipment according to claim 37 said whose metal is platinum.

[Claim 39]

Surface acoustic wave equipment according to claim 37 or 38 which whose Eulerian angles of said piezoelectric substrate are (0° degrees, 90 degrees - 155 degrees, 0° degrees), and has standardization thickness H/lambda of said electrode in the range of 0.01-0.04.

[Claim 40]

Surface acoustic wave equipment according to claim 39 whose standardization thickness Hs/lambda of the Eulerian angle of said LiTaO₃ substrate and said sum total of SiO₂ is either of the combination shown in the following table 12.

[Table 12]

白金 $H/\lambda = 0.01 \sim 0.04$ のとき

SiO ₂ 厚 (H_s/λ)	オイラー角
$0.1 \leq H_s/\lambda < 0.15$	$(0 \pm 3^\circ, 90^\circ \sim 169^\circ, 0 \pm 3^\circ)$
$0.15 \leq H_s/\lambda < 0.2$	$(0 \pm 3^\circ, 90^\circ \sim 167^\circ, 0 \pm 3^\circ)$
$0.20 \leq H_s/\lambda < 0.25$	$(0 \pm 3^\circ, 90^\circ \sim 167^\circ, 0 \pm 3^\circ)$
$0.25 \leq H_s/\lambda < 0.3$	$(0 \pm 3^\circ, 90^\circ \sim 164^\circ, 0 \pm 3^\circ)$
$0.3 \leq H_s/\lambda < 0.4$	$(0 \pm 3^\circ, 90^\circ \sim 163^\circ, 0 \pm 3^\circ)$

[Claim 41]

Surface acoustic wave equipment according to claim 37 or 38 which whose Eulerian angles of said piezoelectric substrate are (0 ± 3 degrees, 102 degrees - 150 degrees, 0 ± 3 degrees), and has standardization thickness H/λ of said electrode in the range of $0.013 \sim 0.033$.

[Claim 42]

Surface acoustic wave equipment according to claim 41 standardization thickness H_s/λ of the sum total of said SiO₂ film and whose Eulerian angle of LiTaO₃ substrate are either of the combination shown in the following table 13.

[Table 13]

白金 $H/\lambda = 0.013 \sim 0.033$ のとき

SiO ₂ 厚 (H_s/λ)	オイラー角
$0.1 \leq H_s/\lambda < 0.15$	$(0 \pm 3^\circ, 106^\circ \sim 155^\circ, 0 \pm 3^\circ)$
$0.15 \leq H_s/\lambda < 0.2$	$(0 \pm 3^\circ, 104^\circ \sim 155^\circ, 0 \pm 3^\circ)$
$0.20 \leq H_s/\lambda < 0.25$	$(0 \pm 3^\circ, 102^\circ \sim 155^\circ, 0 \pm 3^\circ)$
$0.25 \leq H_s/\lambda < 0.3$	$(0 \pm 3^\circ, 102^\circ \sim 154^\circ, 0 \pm 3^\circ)$
$0.3 \leq H_s/\lambda < 0.4$	$(0 \pm 3^\circ, 102^\circ \sim 153^\circ, 0 \pm 3^\circ)$

[Claim 43]

Said piezoelectric substrate is LiTaO₃ substrate of an Eulerian angle (0 ± 3 degrees, 104 degrees - 150 degrees, 0 ± 3 degrees), said 1st and 2nd insulating material layer consists of SiO₂ film, and standardization thickness H_s/λ of the sum total is in the range of $0.10 \sim 0.40$, Surface acoustic wave equipment given in either of claims 1, 4-6 which has standardization thickness H/λ in the range of $0.008 \sim 0.06$ when a

consistency 5000 - 15000 kg/m³ and Young's modulus 2.0×10^{11} - 4.5×10^{11} N/m², or transverse-wave acoustic velocity consists of a metal of 2800 - 3500 m/s and a metal with a larger consistency than said aluminum sets wavelength of H and a surface acoustic wave to λ for the thickness of said electrode.

[Claim 44]

Surface acoustic wave equipment according to claim 43 said whose metal is nickel.

[Claim 45]

Surface acoustic wave equipment according to claim 44 which has standardization thickness H/λ of said electrode in the range of 0.02-0.06.

[Claim 46]

Surface acoustic wave equipment according to claim 44 which has standardization thickness H/λ of said electrode in the range of 0.027-0.06.

[Claim 47]

Surface acoustic wave equipment according to claim 44 the Eulerian angle of said LiTaO₃ substrate and whose standardization thickness H_s/λ of the sum total of said SiO₂ film are either of the combination shown in the following table 14.

[Table 14]

SiO ₂ 膜厚	オイラー角
0.1~0.2	($0 \pm 3^\circ$, $106^\circ \sim 140^\circ$, $0 \pm 3^\circ$)
0.2~0.3	($0 \pm 3^\circ$, $105^\circ \sim 137^\circ$, $0 \pm 3^\circ$)
0.3~0.4	($0 \pm 3^\circ$, $104^\circ \sim 133^\circ$, $0 \pm 3^\circ$)

[Claim 48]

Surface acoustic wave equipment according to claim 43 with which said metal consists of Mo.

[Claim 49]

Surface acoustic wave equipment according to claim 48 which has standardization thickness H/λ of said electrode in the range of 0.017-0.06.

[Claim 50]

Surface acoustic wave equipment according to claim 48 which has standardization thickness H/λ of said electrode in the range of 0.023-0.06.

[Claim 51]

Surface acoustic wave equipment according to claim 48 the Eulerian angle of said LiTaO₃ substrate and whose standardization thickness H_s/λ of the sum total of said SiO₂ film are either of the combination shown in the following table 15.

[Table 15]

SiO ₂ 膜厚	オイラー角
0.1~0.2	($0\pm3^\circ$, $107^\circ \sim 141^\circ$, $0\pm3^\circ$)
0.2~0.3	($0\pm3^\circ$, $104^\circ \sim 141^\circ$, $0\pm3^\circ$)
0.3~0.4	($0\pm3^\circ$, $104^\circ \sim 138^\circ$, $0\pm3^\circ$)

[Claim 52]

Surface acoustic wave equipment given in either of claims 1, 4-6 which is $\rho_0 \times 0.7 \leq \rho \leq \rho_0 \times 1.3$ when said electrode consists of a cascade screen of the main electrode layer which consists of the large metal or large alloy of a consistency rather than aluminum, and at least one electrode layer which consists of other metals and sets the consistency of a metal with a large consistency to ρ_0 rather than the mean density ρ and said aluminum of this electrode.

[Claim 53]

Surface acoustic wave equipment according to claim 1 to 52 whose irregularity of said 2nd insulating material layer front face is 30% or less of the thickness of said electrode.

[Claim 54]

Surface acoustic wave equipment according to claim 1 to 53 characterized by using a leakage type surface acoustic wave as a surface acoustic wave.

[Claim 55]

The process which prepares a piezoelectric substrate,

The process which forms the 1st insulating material layer all over one side of said piezoelectric substrate,

The process which makes the laminated structure of the 1st insulating material layer and a resist remain to the remaining fields while removing the 1st insulating material layer of the part in which said electrode is formed using the resist pattern for forming the electrode pattern which has at least one electrode,

The process which the electrode layer which consists of an alloy which uses the metal or this metal of high density as a principal component is in the 1st insulating material layer, abbreviation, etc. rather than

aluminum by making it the field to which said 1st insulating material layer is removed, forms in thickness, and forms at least one electrode, The process which removes the resist which remains on said 1st insulating material layer,

The manufacture approach of surface acoustic wave equipment equipped with the process which forms the 2nd insulating material layer so that a said 1st insulating material layer and electrode top may be covered.

[Claim 56]

The manufacture approach of surface acoustic wave equipment according to claim 55 that the consistency of the metal which constitutes said electrode, or an alloy is 1.5 or more times of the consistency of said 1st insulating material layer.

[Claim 57]

The process which prepares a piezoelectric substrate,

The process which forms the 1st insulating material layer on the whole surface of one side of said piezoelectric substrate,

The process which the 1st insulating material layer of the field of a part in which said electrode is formed using the resist pattern for forming at least one electrode pattern is removed [process], and makes the laminated structure of the 1st insulating material layer and a resist remain to the remaining fields,

The process which forms the metal or alloy film for forming an electrode in the field to which said 1st insulating material layer is removed, and forms an electrode in it,

The process which forms the protection metal membrane which consists of a metal or an alloy excellent in corrosion resistance all over this electrode, and said protection metal membrane is in the height of said 1st insulating material layer, abbreviation, etc. by carrying out, and forms it in height rather than the metal or alloy which constitutes this electrode after forming said electrode,

The process which removes the protection metal membrane by which the laminating is carried out on the resist on said 1st insulating material layer, and this resist,

The manufacture approach of the surface acoustic wave equipment equipped with the process which forms the 2nd insulating material layer so that the protection metal membrane formed on said electrode and said 1st insulating material layer may be covered.

[Claim 58]

The manufacture approach of surface acoustic wave equipment according to claim 57 that the metal or alloy which constitutes said electrode configuration metal or alloy, and said protection metal membrane so that

the mean density of the laminated structure which consists of said electrode and a protection metal membrane may become 1.5 or more times of the consistency of the 1st insulating material layer is chosen.

[Claim 59]

The process which prepares a piezoelectric substrate,

The process which forms an electrode on said piezoelectric substrate,

The process which forms an insulating material layer so that said electrode may be covered,

The manufacture approach of surface acoustic wave equipment equipped with the process which carries out flattening of the irregularity of the insulating material layer above the part in which said electrode exists, and the part not existing.

[Claim 60]

The manufacture approach of surface acoustic wave equipment according to claim 59 that said flattening process is performed by etchback, a reverse spatter, or polish.

[Claim 61]

The manufacture approach of surface acoustic wave equipment according to claim 55 to 59 using SiO₂ as said insulating material layer using one sort chosen as Au, Cu, Ag, W, Ta, Pt, nickel, and Mo list from the group which consists of an alloy which uses these metals as a principal component as a metal which constitutes said electrode.

[Translation done.]

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DETAILED DESCRIPTION

[Detailed Description of the Invention]

[0001]

[Field of the Invention]

This invention relates to the surface acoustic wave equipment which

equipped the detail with the structure where the insulating material layer is formed so that an IDT electrode may be covered, more, and its manufacture approach about the surface acoustic wave equipment used for a resonator, a band-pass filter, etc., and its manufacture approach.

[0002]

[Description of the Prior Art]

It is called for that a broadband and the both sides of the good temperature characteristic are filled with DPX used for mobile communication system or RF filter. Conventionally, with the surface acoustic wave equipment used for DPX or RF filter, the piezoelectric substrate which consists of 36 degrees - 50 degree rotation Y cut X propagation LiTaO₃ is used. The frequency temperature coefficient of this piezoelectric substrate was about -40--30ppm/degree C. In order to improve the temperature characteristic, the approach of forming SiO₂ film which has a forward frequency temperature coefficient so that an IDT electrode may be covered on a piezoelectric substrate is learned. An example of the manufacture approach of this kind of surface acoustic wave equipment is shown in drawing 109 .

[0003]

As shown in drawing 109 (a), except for the part in which an IDT electrode is formed, a resist pattern 52 is formed on the piezoelectric substrate 51. Next, as shown in drawing 109 (b), the electrode layer 53 for forming an IDT electrode in the whole surface is formed. After an appropriate time, the metal membrane which has adhered on a resist 52 and a resist 52 is removed using resist exfoliation liquid. Thus, as shown in drawing 109 (c), IDT electrode 53A is formed. Next, as shown in drawing 109 (d), SiO₂ film 54 is formed so that IDT electrode 53A may be covered.

[0004]

On the other hand, it is the purpose different from an improvement of the above-mentioned frequency temperature characteristic, and the manufacture approach of surface acoustic wave equipment that the insulating or anti-conductive protective coat is formed so that the IDT electrode of surface acoustic wave equipment may be covered is indicated by the following patent reference 1. Drawing 110 is a typical sectional view showing the surface wave equipment of a publication in this advanced technology. With surface acoustic wave equipment 61, the IDT electrode 63 which consists of an alloy which uses aluminum or aluminum as a principal component is formed on the piezo-electric substrate 62. The insulating or anti-conductive electrode finger mesenteriolum 64 is formed in fields other than the field in which the IDT electrode 63 is

formed. Moreover, the insulating or anti-conductive protective coat 65 is formed so that the IDT electrode 63 and the electrode finger mesenteriolum 64 may be covered. The purport which the above-mentioned electrode finger mesenteriolum 64 and a protective coat 65 consist of with anti-conductivity ingredients, such as insulating materials, such as SiO₂, and silicone, is indicated by surface acoustic wave equipment 61 given in this advanced technology. Here, it is supposed that degradation of the property by discharge between the electrode fingers which originate in the pyroelectricity which the piezo-electric substrate 61 has by formation of the above-mentioned electrode finger mesenteriolum 63 will be controlled.

[0005]

On the other hand, after forming the electrode which consists of metals, such as aluminum metallurgy, on the piezo-electric substrate which becomes the following patent reference 2 from Xtal or lithium niobate and forming SiO₂ film further, 1 port mold surface acoustic wave intermediary resonator which comes to carry out flattening of this SiO₂ film is indicated. Here, it is supposed that the good resonance characteristic will be acquired by flattening.

[0006]

[Patent reference 1]

JP, 11-186866, A

[Patent reference 2]

JP, 6-258355, A

[0007]

[Problem(s) to be Solved by the Invention]

By the manufacture approach of the surface acoustic wave equipment which comes to form membranes SiO₂ film in order to improve the conventional frequency temperature characteristic, as shown in drawing 109, the part in which IDT electrode 53A exists will differ in the height of the front face of SiO₂ film 54 from the part not existing. Therefore, there was a problem that an insertion loss deteriorated, by existence of the irregularity of the SiO₂ film 54 above-mentioned front face. Moreover, this irregularity becomes large as the thickness of an IDT electrode becomes large. Therefore, thickness of an IDT electrode was not able to be thickened.

[0008]

On the other hand, with surface acoustic wave equipment given in reference 1, after the electrode finger mesenteriolum 64 is formed between the electrode fingers of the IDT electrode 63, the protective coat 65 is formed. Therefore, flattening of the front face of a

protective coat 65 can be carried out.

[0009]

However, the IDT electrode 63 was constituted from a configuration of a publication by reference 1 with the alloy which uses aluminum or aluminum as a principal component. Although the electrode finger mesenteriolum 64 was formed so that this IDT electrode 63 might be touched, sufficient reflection coefficient was not able to be obtained in the IDT electrode 63. Therefore, there was a problem that a ripple tended to arise in the resonance characteristic etc., for example.

[0010]

Furthermore, although the resist which preceded forming a protective coat 65 and was formed on the electrode finger mesenteriolum 64 had to be removed by the manufacture approach given in reference 1 using resist exfoliation liquid, there was a possibility that the IDT electrode 63 might be corroded by resist exfoliation liquid in this case. Therefore, the metal which is easy to be corroded was not able to be used as a metal which constitutes an IDT electrode. That is, the class of IDT electrode configuration metal had constraint.

[0011]

On the other hand, although it is shown by 1 port mold surface acoustic wave resonator given in the patent reference 2 mentioned above using Xtal or lithium niobate as a piezo-electric substrate and that an electrode consists of aluminum or gold, only the example in which the electrode which consists of aluminum was formed on the Xtal substrate is shown by the concrete example. That is, reference is not made especially about the surface acoustic wave equipment using other substrate ingredient or other metallic materials.

[0012]

The purposes of this invention are the surface acoustic wave equipment with which the insulating material layer is formed between the electrode fingers of an IDT electrode, and on the IDT electrode, and its manufacture approach, and its reflection coefficient of an IDT electrode is fully large, and they are in view of the present condition of the conventional technique mentioned above to offer the surface acoustic wave equipment which it is hard to produce degradation of the property by the ripple which appears in the resonance characteristic etc., therefore has the good resonance characteristic and a good filter shape, and its manufacture approach.

[0013]

Other purposes of this invention have little constraint of selection of the metallic material with which the reflection coefficient of an IDT

electrode not only has a good, property large enough, but constitutes an IDT electrode, and are to offer the surface acoustic wave equipment which the bad influence by the corrosion of an IDT electrode cannot produce easily, and its manufacture approach.

[0014]

The reflection coefficient of an IDT electrode is fully large, and it has a good property and the purpose of further others of this invention not only cannot produce degradation of the property by the corrosion of an IDT electrode easily, but is to offer surface acoustic wave equipment with the still better frequency temperature characteristic, and its manufacture approach.

[0015]

[Means for Solving the Problem]

As mentioned above, it is shown by by carrying out flattening of the SiO₂ film by the patent reference 2 that the good resonance characteristic is acquired. Then, as a piezo-electric substrate, using LiTaO₃ substrate with a big electromechanical coupling coefficient, others produced 1 port mold surface acoustic wave resonator like the structure of a publication in the patent reference 2, and investigated the property so that invention-in-this-application persons may get the filter of a broadband. That is, the electrode which consists of aluminum was formed on the LiTaO₃ substrate, SiO₂ film was formed, and flattening of the front face of this SiO₂ film was carried out. However, after forming SiO₂ film, the property deteriorated greatly and found out that it was not what can be used.

[0016]

if an electromechanical coupling coefficient uses LiTaO₃ large substrate and LiNbO₃ substrate compared with Xtal, fractional band width will be boiled markedly and will become large. However, when the electrode which consists of aluminum was formed and SiO₂ film was further formed on LiTaO₃ substrate as shown in drawing 2 and drawing 3 as a result of invention-in-this-application persons' performing detailed examination, by carrying out flattening of the front face of SiO₂ film showed that a reflection coefficient decreased sharply to about 0.02. In addition, drawing 2 and drawing 3 are drawings showing relation with a reflection coefficient with electrode layer thickness H/λ of the surface acoustic wave equipment which forms the IDT electrode which consists of aluminum, gold, or platinum by various thickness on the LiTaO₃ substrate of an Eulerian angle (0 degree, 126 degrees, 0 degree), and comes to form SiO₂ film further. In addition, as the continuous line in drawing 2 and drawing 3 shows the front face of SiO₂ film typically in drawing 2

and drawing 3 , it shows change of the reflection coefficient when having not carried out flattening, and a broken line shows change of the reflection coefficient at the time of carrying out flattening of the front face of SiO₂ film.

[0017]

When the electrode which consists of conventional aluminum is used so that clearly from drawing 2 and drawing 3 , by carrying out flattening of the front face of SiO₂ film shows that a reflection coefficient decreases sharply to about 0.02 regardless of electrode layer thickness. For this reason, enough stop bands are no longer obtained and it is thought that a sharp ripple arises near the antiresonant frequency.

[0018]

moreover, as for the reflection coefficient, the thing to which electrode layer thickness increases and which it is alike, it takes and is become large is known conventionally. However, when the electrode which consists of aluminum is used so that clearly from drawing 2 and drawing 3 , even if it enlarges thickness of an electrode, when flattening of the front face of SiO₂ film is carried out, it turns out that a reflection coefficient does not increase.

[0019]

On the other hand, it turns out that a reflection coefficient becomes large as the thickness of an electrode increases when the electrode which consists of Au or Pt is formed so that clearly from drawing 2 and drawing 3 , and flattening of the surface acoustic wave of SiO₂ film is carried out. Invention-in-this-application persons come to make this invention, as a result of examining many things based on such knowledge.

[0020]

At least one IDT electrode which consists of alloys which are formed on the piezoelectric substrate and said piezoelectric substrate, and use the metal or this metal of high density as a principal component rather than aluminum according to invention of the 1st of this application, In the remaining fields except the field in which said at least one IDT electrode is formed It has the 1st insulating material layer which was in said IDT electrode, abbreviation, etc. by carrying out, and was formed in thickness, and the 2nd insulating material layer formed so that said IDT electrode and the 1st insulating material layer might be covered, and the surface acoustic wave equipment with which the consistency of the above-mentioned IDT electrode is made into 1.5 or more times of the consistency of the 1st insulating material layer is offered. In the 1st invention, while the ripple which appears in the resonance characteristic, a filter shape, etc. is moved out of band, a

ripple is oppressed. Therefore, a good property is realizable.

[0021]

At least one IDT electrode which was formed on the piezoelectric substrate and said piezoelectric substrate according to the large aspect of affairs of invention of the 2nd of this application, The protection metal membrane which consists of the metal or alloy which excelled the metal or alloy which is formed on said IDT electrode and constitutes an IDT electrode in corrosion resistance, In the remaining fields except the field in which said at least one IDT electrode is formed Surface acoustic wave equipment equipped with the 1st insulating material layer formed so that the thickness of the sum total of said IDT electrode and protection metal membrane, abbreviation, etc. might be by carrying out and it might have thickness, and the 2nd insulating material layer formed so that said protection metal membrane and the 1st insulating material layer might be covered is offered.

[0022]

On a specific aspect of affairs with the 2nd invention, mean density of the laminated structure which consists of the above-mentioned IDT electrode and a protection metal membrane is made into 1.5 or more times of the consistency of the 1st insulating material layer, and the unnecessary ripple which appears on the resonance characteristic or a filter shape by it is shifted out of band, and resonates.

[0023]

On a specific aspect of affairs with the 1st and the 2nd invention, the above 1st and the 2nd insulating material layer are formed of SiO₂, and the frequency temperature characteristic can offer good surface acoustic wave equipment by it.

[0024]

The surface acoustic wave equipment concerning the 1st and 2nd invention is surface acoustic wave equipment using reflection of a surface acoustic wave preferably. You may be surface acoustic wave equipment which it could be limited, but the end-face reflective mold surface acoustic wave equipment using reflection of opposite 2 end face of a piezoelectric substrate could be constituted especially as structure of using reflection of a surface acoustic wave, or prepared the reflector in the surface acoustic wave propagation direction outside of IDT.

[0025]

The surface acoustic wave equipment concerning the 1st and 2nd invention can be used for various surface acoustic wave resonators or a surface acoustic wave filter. Such a surface acoustic wave resonator may be 1 port mold resonator, and you may be 2 port mold resonator, and a surface

acoustic wave filter may be 2 port mold resonator filter, and may be a ladder mold filter or a lattice mold filter.

[0026]

On a specific aspect of affairs with the surface acoustic wave equipment concerning the 1st and 2nd invention, the above-mentioned electrode is an IDT electrode. On the other hand, an IDT electrode may be a tropism electrode, and can reduce an insertion loss by it.

[0027]

Moreover, the above-mentioned electrode may be a reflector.

On a specific aspect of affairs with the surface acoustic wave equipment concerning the 1st and 2nd invention, the above-mentioned electrodes are an IDT electrode and a reflector electrode.

[0028]

On a specific aspect of affairs with the 1st and the 2nd invention, said piezoelectric substrate is LiTaO₃ substrate of an Eulerian angle (0°-3 degrees, 104 degrees - 140 degrees, 0°-3 degrees). When wavelength of H_s and a surface acoustic wave is set to λ , the sum total thickness of SiO₂ film which the said 1st and 2nd insulating material layer consists of SiO₂, and constitutes the 1st and 2nd insulating material layer When H_s/ λ is made into the range of 0.03-0.45 and sets wavelength of H and a surface acoustic wave to λ for the thickness of said electrode, let standardization thickness H/ λ of an electrode be the value with which the following formula (1) is filled.

$0.005 \leq H/\lambda \leq 0.00025\rho^2 - 0.01056\rho + 0.16473$ (however, ρ mean density of an electrode) -- Formula (1)

[0029]

As the metal which constitutes an electrode from the 1st invention as mentioned above,

A metal is used. As such a metal, Au, Ag, Cu, W, Ta, Pt, nickel, or Mo is mentioned.

[0030]

the main metal membrane which consists of the alloys which make these metals or these metals a subject so that it may mention later in this invention, these metals, or an alloy, and the metal membrane of at least one layer which consists of other metals -- ** -- an electrode may be constituted by the cascade screen. In this case, it considers as the specific range, and an electromechanical coupling coefficient and a reflection coefficient can be raised, and standardization thickness H_s/ λ of the sum total of this SiO₂ film at the time of constituting the Eulerian angle [of standardization thickness H/ λ of an electrode and a piezoelectric substrate] and 1st, and 2nd insulating

material layer from SiO₂ film according to a metal class can realize the good frequency temperature characteristic. Moreover, the fall of an attenuation coefficient can also be aimed at by choosing each above-mentioned range.

[0031]

The process which invention of the 3rd of this application is the manufacture approach of the surface acoustic wave equipment concerning the 1st invention, and prepares a piezoelectric substrate, While removing the 1st insulating material layer of the part in which said IDT electrode is formed using the resist pattern for forming the electrode pattern which has the process which forms the 1st insulating material layer all over one side of said piezoelectric substrate, and at least one IDT electrode The process which makes the laminated structure of the 1st insulating material layer and a resist remain to the remaining fields, The process which the electrode layer which consists of an alloy which uses the metal or this metal of high density as a principal component is in the 1st insulating material layer, abbreviation, etc. rather than aluminum by making it the field to which said 1st insulating material layer is removed, forms in thickness, and forms at least one IDT electrode, It is characterized by having the process which removes the resist which remains on said 1st insulating material layer, and the process which forms the 2nd insulating material layer so that a said 1st insulating material layer and IDT electrode top may be covered.

[0032]

Also in the manufacture approach of the surface acoustic wave equipment concerning the 3rd invention, preferably, the consistency of the metal which constitutes the above-mentioned IDT electrode, or an alloy is made into 1.5 or more times of the consistency of the 1st insulating material layer, and the unnecessary ripple which appears on the resonance characteristic or a filter shape is shifted out of band, and it resonates.

[0033]

Invention of the 4th of this application is the manufacture approach of surface acoustic wave equipment, and is for obtaining the surface acoustic wave equipment concerning the 2nd invention. The process for which the 4th invention prepares a piezoelectric substrate, and the process which forms the 1st insulating material layer on the whole surface of one side of said piezoelectric substrate, The process which the 1st insulating material layer of the field of a part in which said electrode is formed using the resist pattern for forming at least one IDT electrode pattern is removed [process], and makes the laminated

structure of the 1st insulating material layer and a resist remain to the remaining fields, The metal or alloy film for forming an IDT electrode in the field to which said 1st insulating material layer is removed is formed. The process which forms an IDT electrode, and after forming said IDT electrode The process which forms the protection metal membrane which consists of a metal or an alloy excellent in corrosion resistance all over this IDT electrode, and said protection metal membrane is in the height of said 1st insulating material layer, abbreviation, etc. by carrying out, and forms it in height rather than the metal or alloy which constitutes this IDT electrode, It is characterized by having the process which removes the protection metal membrane by which the laminating is carried out on the resist on said 1st insulating material layer, and this resist, and the process which forms the 2nd insulating material layer so that the protection metal membrane formed on said IDT electrode and said 1st insulating material layer may be covered.

[0034]

Also in the 4th invention, like the 2nd invention, preferably, mean density of the laminated structure which consists of an IDT electrode and a protection metal membrane is made into 1.5 or more times of the consistency of the 1st insulating material layer, and the unnecessary ripple which appears on the resonance characteristic or a filter shape is shifted out of band, and it resonates.

[0035]

Invention of the 5th of this application is the manufacture approach of surface acoustic wave equipment equipped with the process which carries out flattening of the irregularity of the insulating material layer above the process which prepares a piezoelectric substrate, the process which forms an electrode on said piezoelectric substrate, the process which forms an insulating material layer so that said electrode may be covered, the part in which said electrode exists, and the part not existing.

[0036]

In the 5th invention, the above-mentioned flattening process is preferably performed by etchback, a reverse spatter, or polish.

[0037]

[Embodiment of the Invention]

Hereafter, this invention is clarified by explaining the concrete example of this invention, referring to a drawing.

[0038]

With reference to drawing 1 and drawing 6 , the manufacture approach of

the surface acoustic wave equipment concerning the 1st example of this invention is explained.

As shown in drawing 1 (a), LiTaO₃ substrate 1 is first prepared as a piezoelectric substrate. At this example, LiTaO₃ substrate of (0 degree, 126 degrees, 0 degree) is used by 36-degree Y cut X propagation and the Eulerian angle. But what may use LiTaO₃ substrate of other crystal orientation, or consists of other piezo-electric single crystals as a piezoelectric substrate may be used. Moreover, the piezoelectric substrate which comes to carry out the laminating of the piezoelectric thin film may be used on an insulating substrate. In addition, there is relation of +90 degrees of $\theta = \text{cut angles of an Eulerian angle } (\phi, \theta, \psi)$.

[0039]

On LiTaO₃ substrate 1, the 1st insulating material layer 2 is formed on the whole surface. In this example, the 1st insulating material layer 2 is formed with SiO₂ film.

The formation approach of the 1st insulating material layer 2 may be performed by proper approaches, such as printing, vacuum evaporation, or sputtering. Moreover, thickness of the 1st insulating material layer 2 is made equal to the thickness of the IDT electrode formed later.

[0040]

Next, as shown in drawing 1 (b), a resist pattern 3 is formed using a photolithography technique. The resist pattern 3 consists of resist patterns 3 so that a resist may be located except for the field in which IDT is formed.

[0041]

Next, the remaining part except the part located under the resist 3 among the 1st insulating material layers 2 is removed by the reactive-ion-etching method (RIE) which irradiates an ion beam at drawing 1 (c) as an arrow head shows.

[0042]

When SiO₂ is etched by RIE by the gas of a fluorine system, residue may arise by the polymerization reaction. In this case, after performing RIE, it can respond by processing by BHF (buffered fluoric acid) etc.

[0043]

After an appropriate time, Cu film and Ti film are formed in thickness equal to the 1st insulating material layer 2. As shown in drawing 1 (d), the Cu film 4 is given to the field where the 1st insulating material layer 2 is removed, i.e., the field in which IDT is formed, and the Cu film 4 is given to coincidence also on a resist pattern 3. Next, the Ti film 5 is formed as a complete protection metal membrane. As shown in

drawing 1 (e), the Ti film 5 will be given on the top face of IDT electrode 4A, and the Cu film 4 on a resist pattern 3. Therefore, a side face is covered with the 1st insulating material layer 2, and, as for IDT electrode 4A, the top face is covered with the Ti film 5. Thus, IDT electrode 4A and a protection metal membrane are formed, and it is constituted so that the thickness of IDT electrode 4A, the thickness of the sum total of the thickness of the Ti film 5 as a protection metal membrane, and the thickness of the 1st insulating material layer 2 may have the same thickness.

[0044]

After an appropriate time, a resist pattern 3 is removed using resist exfoliation liquid. Thus, as shown in drawing 1 R> 1 (f), IDT electrode 4A is formed in the remaining fields except the field in which the 1st insulating material layer 2 is formed, and the structure where the top face of IDT electrode 4A is covered with the Ti film 5 is acquired.

[0045]

As shown in drawing 1 (g) after an appropriate time, SiO₂ film is formed in the whole surface as the 2nd insulating material layer 6.

Thus, the surface acoustic wave resonator 11 of 1 port mold shown in drawing 6 was obtained.

[0046]

In addition, only the part in which IDT electrode 4A is formed was extracted and explained by drawing 1 (a) - (g). However, the surface acoustic wave resonator 11 equips the surface acoustic wave propagation direction both sides of IDT electrode 4A with reflectors 12 and 13 as shown in drawing 6. Reflectors 12 and 13 are also formed of the same process as IDT electrode 4A.

[0047]

Although one IDT electrode 4A was formed on LiTaO₃ substrate 1 in the above-mentioned example since 1 port mold surface acoustic wave resonator 11 was constituted, according to the application of surface acoustic wave equipment, two or more IDT electrodes may be formed, and a reflector may be formed of the same process as IDT as mentioned above, and a reflector is not prepared, but ** is also good.

[0048]

For the comparison, 1 port mold surface acoustic wave resonator was produced according to the manufacture approach of surface acoustic wave equipment of having SiO₂ conventional film shown in drawing 109. But also in this example of a comparison, the IDT electrode was formed by Cu, using LiTaO₃ substrate of 36-degree rotation Y cut X propagation (they are (0 degree, 126 degrees, 0 degree) at an Eulerian angle) as a

substrate ingredient. Since SiO₂ film 54 was formed after IDT electrode 53A is formed so that clearly from the manufacture approach shown in drawing 109 , irregularity could not but arise on the front face of SiO₂ film 54. In the example of a comparison, the impedance characteristic and phase characteristic at the time of setting to 0.042 standardization thickness h/λ (h being the thickness of an IDT electrode and λ being the wavelength of a surface acoustic wave) of the IDT electrode which consists of Cu, and carrying out standardization thickness H_s/λ (H_s being the thickness of SiO₂ film) of SiO₂ film to 0.11, and 0.22 and 0.33 are shown in drawing 4 . It turns out that the impedance ratio which is a ratio of the impedance in an antiresonance point and the impedance in the resonance point becomes small as standardization thickness H_s/λ of SiO₂ film becomes large so that clearly from drawing 4 .

[0049]

Moreover, drawing 5 shows the relation between standardization thickness H_s/λ of SiO₂ film of a surface acoustic wave resonator manufactured in the example of a comparison, and MF (Figure of Merit) of a resonator. It turns out that MF falls as the thickness of SiO₂ film becomes thick so that clearly from drawing 5 .

[0050]

That is, the property deteriorated greatly as the thickness of SiO₂ film became thick even if it formed the IDT electrode by Cu when an IDT electrode and SiO₂ film were formed according to the conventional method shown in drawing 109 . This is considered to be because for the irregularity mentioned above on the SiO₂ film front face to arise.

[0051]

On the other hand, according to the manufacture approach of this example, even when the thickness of SiO₂ film is made to increase, it is shown in that it is hard to produce degradation of a property, and drawing 7 -9. Drawing 7 is the change **** Fig. of the impedance characteristic at the time of changing the thickness of SiO₂ film at the time of obtaining the surface acoustic wave resonator 11 according to the above-mentioned example, i.e., the thickness of the 2nd insulating material layer 6, and a phase characteristic. Moreover, the broken line of drawing 8 and drawing 9 is drawing showing change of the resonator at the time of changing thickness H_s/λ of SiO₂ film in an example of γ and MF, respectively.

[0052]

In addition, in drawing 8 and drawing 9 , a continuous line shows the result of the above-mentioned example of a comparison.

If drawing 7 is compared with drawing 4 , even if it makes standardization thickness H_s/λ of SiO₂ film increase compared with the case of the example of a comparison, in the above-mentioned example, it turns out that it is hard to produce the fall of an impedance, so that clearly.

[0053]

Moreover, according to the manufacture approach of an example, compared with the example of a comparison, it turns out that degradation of the property accompanying the increment in standardization thickness H_s/λ of SiO₂ film is controlled so that clearly from the result of drawing 8 and drawing 9 .

[0054]

That is, according to the manufacture approach of this example, even if it is the case where the thickness of SiO₂ film is made to increase as mentioned above, it is hard to produce the fall of an impedance ratio, and degradation of a property can be controlled.

[0055]

On the other hand, drawing 10 is drawing showing the relation between the thickness of SiO₂ film, and the frequency temperature characteristic TCF of the surface acoustic wave resonator obtained by the manufacture approach of the example of a comparison, and an example.

In drawing 10 , a continuous line shows the example of a comparison and a broken line shows the result of an example.

[0056]

When the thickness of SiO₂ film is made to increase so that clearly from drawing 10 according to the manufacture approach of an example, it turns out that the frequency temperature characteristic TCF can be ideally improved according to the increase of thickness.

[0057]

Therefore, by adopting the manufacture approach of the above-mentioned example shows that it is hard to produce degradation of a property and the surface acoustic wave resonator which can improve the temperature characteristic effectively can be offered.

In addition, by the manufacture approach of this example, the IDT electrode is constituted from aluminum by Cu of high density. Therefore, IDT electrode 4A has sufficient reflection coefficient, and can control the ripple which is not the request which appears on the resonance characteristic. This is explained below.

[0058]

If it removed having replaced with Cu and having used aluminum film, the surface acoustic wave resonator of the 2nd example of a comparison was

produced like the above-mentioned example. However, standardization thickness H_s/λ of SiO₂ film was set to 0.08. That is, standardization thickness of the thickness of the 1st insulating material layer was set to 0.08. Thus, a continuous line shows the impedance and phase characteristic of a surface acoustic wave resonator which were acquired to drawing 11 .

[0059]

Moreover, if it removes having not formed SiO₂ film, a broken line shows the impedance and phase characteristic of a surface acoustic wave resonator which were constituted like the 2nd example of a comparison to drawing 11 .

[0060]

When an IDT electrode is formed with aluminum and SiO₂ film is formed even if it follows the manufacture approach of the above-mentioned example so that clearly from the continuous line of drawing 11 , it turns out that the big ripple shown by the arrow head A of drawing 11 appears between the resonance point and an antiresonance point. Moreover, it turns out that such a ripple does not appear in the surface acoustic wave resonator which does not have SiO₂.

[0061]

Therefore, even if it is going to aim at an improvement of the frequency temperature characteristic etc. by formation of SiO₂ film, when an IDT electrode is formed by aluminum, it turns out that the above-mentioned ripple A appears and degradation of a property is caused. As a result of inquiring to a pan per this point, when using the metal of high density rather than aluminum as an IDT electrode, the invention-in-this-application person could raise the reflection coefficient of an IDT electrode, and found out that the above-mentioned ripple A could be controlled by it.

[0062]

That is, according to the same manufacture approach as the above-mentioned example, various consistencies of the metal which constitutes the IDT electrode 4 were changed, and the surface acoustic wave resonator was produced like the above-mentioned example. Thus, the impedance characteristic of the obtained surface acoustic wave resonator is shown in drawing 12 (a) - (e). Drawing 1212 (a) The ratios

[respectively as opposed to the consistency ρ_2 of the 1st insulating material layer of the mean density ρ_1 of the laminated structure of an IDT electrode and a protection metal membrane in - (e)] ρ_1/ρ_2 show the result in 2.5, 2.0, 1.5, 1.2, and 1.0.

[0063]

Drawing 12 (a) At drawing 12 (a) - (c), the above-mentioned ripple A is shifted out of band, and it turns out further by drawing 12 (a) that the above-mentioned ripple A is oppressed remarkably so that clearly from - (e).

[0064]

Therefore, the result of drawing 12 shows that shift 1.5 or more times, then the above-mentioned ripple A to the outside of the band of resonance frequency-antiresonant frequency, and a good property is acquired in the density ratio to the 1st insulating material layer of the laminated structure of an IDT electrode and a protection metal membrane. Moreover, it turns out more preferably that 2.5 or more times, then the ripple itself can be made small for the above-mentioned density ratio.

[0065]

Drawing 12 (a) Although the above-mentioned mean density was used in - (e) since the laminating of the Ti film was carried out on IDT electrode 4A according to the above-mentioned example, in this invention, a protection metal membrane is not prepared on IDT electrode 4A, but ** is also good. In that case, it was desirable to have made thickness of IDT electrode 4A the same as the thickness of the 1st insulating material layer, and to have made the ratio to the consistency of the 1st insulating material layer of the consistency of an IDT electrode into 1.5 or more times, more preferably, it was good and it was confirmed 2.5 or more times, then that the same effectiveness as the above is acquired.

[0066]

Therefore, in the surface acoustic wave resonator which comes to cover an IDT electrode with SiO₂ film, if the consistency of an IDT electrode or mean density of the layered product of an IDT electrode and a protection metal membrane is made larger than the consistency of the 1st insulating material layer located in the side of an IDT electrode, it turns out that the reflection coefficient of an IDT electrode can be raised and degradation of the property which appears between resonance point-antiresonance points by it can be controlled.

[0067]

In addition, as the metal or alloy of high density, the alloy which makes others, Ag, Au, etc. and these a subject is mentioned from aluminum. [Cu]

Moreover, since the side face of IDT electrode 4A is covered with the 1st insulating material layer 2 and the top face is covered with the protection metal membrane 6 on the IDT electrode like [it is desirable and] the above-mentioned example in case a resist pattern 3 is

exfoliated so that clearly from the structure which carried out the laminating of the protection metal membrane, then the manufacture approach which showed drawing 1 (a) - (g), the corrosion of IDT electrode 4A can be prevented. Therefore, it turns out that the surface acoustic wave resonator which has a much more good property can be offered.

[0068]

Furthermore, the 1st and 2nd insulating material layer may be formed with an insulating ingredient with other temperature characteristic improvement effects, such as $\text{SiO}_x\text{N}(\text{ies})$ other than SiO_2 . Moreover, the 1st and 2nd insulating material layer may consist of different insulating ingredients, and may consist of ingredients equal as mentioned above.

[0069]

Drawing 13 is drawing showing the relation of an electromechanical coupling coefficient with standardization thickness H/λ of IDT at the time of forming an IDT electrode using various metals by various thickness on the LiTaO_3 substrate of an Eulerian angle (0 degree, 126 degrees, 0 degree).

[0070]

When the standardization thickness of the electrode with which an electromechanical coupling coefficient becomes large compared with aluminum obtained from drawing 13 was investigated about each metal, the result shown in drawing 14 was obtained. That is, drawing 14 is drawing showing the electrode layer Atsunori enclosure where an electromechanical coupling coefficient becomes large compared with the case where the IDT electrode which consists of aluminum as mentioned above is formed, when the IDT electrode which consists of a metal of various consistencies is formed on the above-mentioned LiTaO_3 substrate.

[0071]

In drawing 14, among the thickness range of the electrode which consists of each metal, an electromechanical coupling coefficient is the threshold value of the range which becomes large, and, as for the minimum of the electrode layer Atsunori enclosure of each metal, an upper limit shows a production limitation rather than aluminum. It will be set to $y=0.00025x^2-0.01056x+0.16473$ if an upper limit is approximated by the quadratic, using a consistency as x using the range of electrode layer thickness with a big electromechanical coupling coefficient as y .

[0072]

Therefore, the electrode is formed on the piezo-electric substrate which

consists of LiTaO₃ of 14 degrees - 50 degree rotation Y cut X propagation (they are (0 degree, 104 degrees - 140 degrees, 0 degree) at an Eulerian angle), and standardization thickness H/λ of an electrode further SiO₂ film in the structure currently formed in the range of standardization thickness H_s/λ 0.03-0.45 so that clearly from explanation of the concrete example according to each below-mentioned electrode material,

$0.005 \leq H/\lambda \leq 0.00025\rho^2 - 0.01056\rho + 0.16473$ -- Formula (1)

A ***** case, an electromechanical coupling coefficient can be raised so that clearly from the result of drawing 14 . In addition, ρ shows the mean density of an electrode.

[0073]

In this invention, an electrode is characterized by consisting of aluminum mentioned above using a metal with a high consistency. In this case, the electrode may consist of alloys which may consist of metals with a consistency higher than aluminum, or make aluminum a subject. moreover, it consists of a different metal from the main metal membrane which consists of an alloy which uses aluminum or aluminum as a principal component, and this metal membrane -- ** -- you may consist of laminated structures of a metal membrane. When the electrode is constituted by the cascade screen and the consistency of the metal of ρ and a main electrode layer is set to $\rho = 0$ for the mean density of an electrode, what is necessary is just the mean density which satisfies $\rho \times 0.7 \leq \rho \leq \rho \times 1.3$.

[0074]

Moreover, in this invention, although flattening of the front face of the 2nd insulating material layer is carried out as mentioned above, this flattening should just have 30% or less of irregularity of the thickness of an electrode. If it exceeds 30%, the effectiveness by flattening may not fully be acquired.

[0075]

Furthermore, flattening of the 2nd insulating material layer is performed by various approaches as mentioned above. For example, the flattening approach by etchback, the flattening approach using the oblique incidence effectiveness by the reverse spatter effectiveness, the approach of grinding an insulating material layer front face, or the approach of grinding an electrode is mentioned. As for these approaches, two or more sorts may be used together. Drawing 102 - Fig. 105 is explained for the detail of these approaches.

[0076]

Drawing 102 (a) - (c) is the approach of carrying out flattening of the

insulating material layer front face by the etchback approach. First, as shown in drawing 102 (a), on the piezoelectric substrate 41, an electrode 42 is formed and the insulating material layer 43 is formed after an appropriate time. As shown in drawing 102 (b), a resist 44 is formed of spin coating etc. on the insulating material layer 43. The front face of a resist 44 is flat. Therefore, flattening of the front face of the insulating material layer 43 which consists of SiO₂ etc. can be carried out by etching by reactive ion etching, i.e., etchback, from this condition (drawing 102 (c)).

[0077]

Drawing 103 (a) - (d) is each typical sectional view for explaining a reverse sputter. Here, an electrode 42 is formed on the piezoelectric substrate 41, and the insulating material layer 43 is formed after an appropriate time. And argon ion etc. is irradiated on the front face of the insulating material layer 43 by sputtering. This ion is used in order to carry out the sputter of the substrate 41. When ion collides with a substrate and performs sputtering, the sputter effectiveness that the direction in the case of carrying out incidence to a slanting field is big is acquired rather than it carries out incidence to a flat field. This is known as oblique incidence effectiveness. Flattening of it is carried out by this effectiveness as are shown in drawing 103 (b) - (d) and the front face of the insulating material layer 43 advances sputtering.

[0078]

Drawing 104 (a) and (b) are the typical sectional views for explaining how carrying out flattening by grinding an insulating material layer. As shown in drawing 104 (a), after forming an electrode 42 and the insulating material layer 43 on a substrate 41, flattening of the front face of the insulating material layer 43 can be carried out by grinding mechanically or chemically.

[0079]

Drawing 105 (a) - (c) is the approach of attaining flattening, by grinding an electrode. Here, as shown in drawing 105 (a), after forming the 1st insulating material layer 45 on a substrate 41, vacuum evaporation etc. forms in the whole surface metal membrane 42A which consists of an electrode material. As shown in drawing 105 (b) after an appropriate time, the 1st insulating material layer 45 formed in the field around the field in which the electrode 42 and the electrode 42 are formed is formed by grinding metal membrane 42A mechanically or chemically. Thus, the 1st insulating material layer 45 and the top face of an electrode 42 are made flat-tapped, and flattening is carried out.

As shown in drawing 105 (c) after an appropriate time, an insulating material layer with a flat front face can be formed by forming the 2nd insulating material 46.

[0080]

This invention is applicable to various surface acoustic wave equipments. The example of such surface acoustic wave equipment is shown in drawing 106 (a), (b) - Fig. 108 . Drawing 106 (a) and (b) are the typical top views showing the electrode structure of 1 port mold surface acoustic wave resonator 47 and 2 port mold surface acoustic wave resonator 48, respectively. Moreover, 2 port mold surface acoustic wave resonator filter may be constituted using the same electrode structure as 2 port mold surface acoustic wave resonator 48 shown in drawing 106 (b).

[0081]

Furthermore, Fig. 107 and 108 is a typical top view showing the electrode structure of a ladder mold filter and a lattice mold filter, respectively. By forming electrode structure like ladder mold filter 49a shown in Fig. 107 and 108 , and lattice mold filter 49b on a piezoelectric substrate, a ladder mold filter and a lattice mold filter can be constituted according to this invention.

[0082]

But this invention is applicable not only to the surface acoustic wave equipment which has the electrode structure shown in Fig. 106 and 107 but various surface acoustic wave equipments.

Moreover, the surface acoustic wave equipment using a leakage elastic wave consists of preferably surface acoustic wave equipment concerning this invention. It is surface acoustic wave equipment which has the electrode which becomes JP,6-164306,A from heavy metals, such as Au, and the surface acoustic wave equipment using a Love wave without propagation attenuation is indicated. Here, by using a heavy metal as an electrode, acoustic velocity of the surface acoustic wave to spread is made later than a transverse-wave bulk wave with a late substrate, a leakage component is lost and the Love wave as a non-revealing surface acoustic wave is used by it.

[0083]

However, in the above-mentioned Love wave, acoustic velocity cannot but become slow inevitably and the pitch of IDT cannot but become small in connection with it. Therefore, the difficulty of processing becomes high and process tolerance deteriorates. In addition, the line breadth of IDT also becomes small and loss by resistance also increases. Therefore, loss cannot but become large.

[0084]

On the other hand, in this invention, in spite of using the electrode which consists of a metal heavier than aluminum unlike the surface acoustic wave equipment which used the above Love waves, the quick leakage surface acoustic wave of acoustic velocity can be used suitably, and even if it is that case, reduction of a propagation loss can be aimed at. Therefore, the surface acoustic wave equipment of low loss can be constituted.

[0085]

Hereafter, suppose that it explains for every metallic material about each example when a metal with a large consistency constitutes an electrode from aluminum based on the result mentioned above.

With in addition, a metal with a larger consistency than aluminum used by this invention (1) The metal a consistency 15000 - 23000 kg/m³ and Young's modulus 0.5x10¹¹ - 1.0x10¹¹ N/m², or whose transverse-wave acoustic velocity is 1000 - 2000 m/s, For example, the metal Au, the (2) consistency 5000 - 15000 kg/m³ and Young's modulus 0.5x10¹¹ - 1.0x10¹¹ N/m², or whose transverse-wave acoustic velocity is 1000 - 2000 m/s, For example, the metal Ag, the (3) consistency 5000 - 15000 kg/m³ and Young's modulus 1.0x10¹¹ - 2.05x10¹¹ N/m², or whose transverse-wave acoustic velocity is 2000 - 2800 m/s, For example, the metal Cu, the (4) consistency 15000 - 23000 kg/m³ and Young's modulus 2.0x10¹¹ - 4.5x10¹¹ N/m², or whose transverse-wave acoustic velocity is 2800 - 3500 m/s, For example, the metal a tungsten, the (5) consistency 15000 - 23000 kg/m³ and Young's modulus 1.0x10¹¹ - 2.0x10¹¹ N/m², or whose transverse-wave acoustic velocity is 2000 - 2800 m/s, For example, the metal a tantalum, the (6) consistency 15000 - 23000 kg/m³ and Young's modulus 1.0x10¹¹ - 2.0x10¹¹ N/m², or whose transverse-wave acoustic velocity is 1000 - 2000 m/s, For example, the metal platinum, the (7) consistency 5000 - 15000 kg/m³ and Young's modulus 2.0x10¹¹ - 4.5x10¹¹ N/m², or whose transverse-wave acoustic velocity is 2800 - 3500 m/s, for example, nickel and Mo, is mentioned.

[0086]

[The example to which an electrode makes Au a subject]

Drawing 15 is a top view for explaining the vertical joint resonator filter as surface acoustic wave equipment concerning other examples of this invention.

[0087]

Surface acoustic wave equipment 21 has the structure in which IDT(s) 23a and 23b and Reflectors 24a and 24b were formed on the top face of LiTaO₃ substrate 22. Moreover, SiO₂ film 15 is formed so that IDT(s) 23a and 23b and Reflectors 24a and 24b may be covered. In addition, as LiTaO₃

substrate 22, 25 degrees - 58 degree rotation Y cut X propagation (Eulerian angle (0-degree, 115 degrees - 148 degree, 0 degree)) LiTaO₃ substrate is used. In this rotation Y cut X propagation LiTaO₃ substrate of a cut angle out of range, an attenuation coefficient is large and TCF also gets worse.

[0088]

IDT(s) 23a and 23b and Reflectors 24a and 24b are constituted by the metal with a high consistency compared with aluminum. Even if at least one sort of metals chosen from the group which consists of Au, Pt, W, Ta, Ag, Mo, Cu, nickel, Co, Cr, Fe, Mn, Zn, and Ti as such a metal, or this ** is not, the alloy which uses one of them as a principal component is mentioned.

[0089]

As mentioned above, since IDT(s) 23a and 23b and Reflectors 24a and 24b are constituted by the metal with a high consistency compared with aluminum, even if it is the case where thickness of IDT(s) 23a and 23b and Reflectors 24a and 24b is made thin compared with the case where aluminum is used, as shown in drawing 16 and drawing 17, an electromechanical coupling coefficient and a reflection coefficient can be raised.

[0090]

And electrode layer thickness can be made thin as mentioned above. About the thickness of SiO₂ film 25, it is desirable that the range of thickness H_s/λ standardized on the wavelength of a surface acoustic wave is 0.03-0.45 so that clearly from the below-mentioned example of an experiment. In addition, the thickness of the sum total when H_s constitutes the 1st and 2nd insulating material layer from SiO₂, and λ show the wavelength of a surface acoustic wave. By making it this range, an attenuation coefficient can be sharply made small and low loss-ization is attained from the case where there is no SiO₂ film.

[0091]

Although it changes also with ingredients which constitute IDT, when consisting of Au film, for example, as for the thickness standardized on the wavelength of the surface acoustic wave of IDT(s) 23a and 23b, 0.013-0.030 are desirable. Since IDT lengthens and it has surroundings resistance when Au film is thin, 0.021-0.03 are more preferably desirable.

[0092]

With the surface acoustic wave equipment which this invention requires, as mentioned above, IDT(s) 23a and 23b are constituted from aluminum on LiTaO₃ substrate 22 by the metal with a large consistency, and this

electrode layer thickness of IDT(s) 23a and 23b can be made thin. Therefore, it has a good property and the good frequency temperature characteristic is realized by formation of SiO₂ film 25. This is explained based on a concrete example.

[0093]

When IDT which consists of aluminum is formed on the LiTaO₃ substrate of (0 degree, 126 degrees, 0 degree) by 36-degree rotation Y cut X propagation and the Eulerian angle, change of the electromechanical coupling coefficient K_{sa} at the time of forming by the various thickness of IDT which consists of Au, Ta, Ag, Cr, W, Cu, Zn, Mo, and nickel and an attenuation coefficient (α), and reflection coefficient $|r_{\text{ref}}|$ is shown in drawing 16, drawing 18, and drawing 17, respectively. in addition, numerical calculation -- the approach of J. J. Campbell and W. R. Jones: IEEE Trans. Sonic&Ultrason. SU-15. p209 (1968) -- following -- an electrode -- the whole surface -- it calculated as uniform.

[0094]

When standardized thickness H/λ is 0.10 in IDT which consists of aluminum so that clearly from drawing 16, an electromechanical coupling coefficient K_{sa} is about 0.27. In addition, H shows thickness and λ shows the wavelength of a surface acoustic wave. On the other hand, in IDT which consists of Au, Ta, Ag, Cr, W, Cu, Zn, Mo, and nickel, when H/λ is made into the range of 0.013-0.035, the bigger electromechanical coupling coefficient K_{sa} can be realized. However, by IDT which consists of Au, Ta, Ag, Cr, W, Cu, Zn, Mo, and nickel, an attenuation coefficient becomes very large to an attenuation coefficient α being about 0 regardless of thickness H/λ at IDT which consists of aluminum so that clearly from drawing 18.

[0095]

Drawing 25 is drawing in the structure which formed IDT and SiO₂ film which consists of Au on the LiTaO₃ substrate of (0 degree, θ , 0 degree) by the Eulerian angle showing relation with an electromechanical coupling coefficient with θ . Here, when standardization thickness of IDT which consists of Au was set to 0.022, 0.025, and 0.030, standardization thickness H_s/λ of SiO₂ film was changed to the list with 0.00 (SiO₂ film is not formed), 0.10, 0.20, and 0.30 and 0.45.

[0096]

It turns out that SiO₂ film takes for becoming thick and an electromechanical coupling coefficient K_{sa} becomes small so that clearly from drawing 25. Moreover, in order to control degradation of the property by SiO₂ film so that it may mention later, the case where

thickness of IDT is made thin is considered. Even when standardization thickness is made thin to 0.04 in IDT which consists of conventional aluminum so that clearly from above-mentioned drawing 16 and SiO₂ film is not formed, an electromechanical coupling coefficient K_{aw} becomes small with 0.245. Moreover, when standardization thickness of IDT which consists of aluminum is set to 0.04 and SiO₂ film is formed, an electromechanical coupling coefficient K_{aw} becomes still smaller, and broadband-ization becomes difficult practically.

[0097]

On the other hand, with the structure which formed IDT which consists of Au and formed SiO₂ film, even if it is the case where standardization thickness H_s/λ of SiO₂ film is made about into 0.45 by making theta of an Eulerian angle into 128.5 degrees or less, it turns out that an electromechanical coupling coefficient K_{aw} becomes 0.245 or more, so that clearly from drawing 25 . Moreover, when standardization thickness forms SiO₂ film which is about 0.30, an electromechanical coupling coefficient K_{aw} can be made or more into 0.245 by making theta of an Eulerian angle into 132 degrees or less. In addition, when smaller than 115 degrees, an attenuation coefficient becomes large and theta of an Eulerian angle is not practical, so that it may mention later. Therefore, it turns out that it is suitable 25 degrees - 42 degree rotation Y cut X propagation (being an Eulerian angle (0**3 degrees, 115 degrees - 132 degrees, 0**3 degrees)) and to use LiTaO₃ substrate of 25 degrees - 38.5 degree rotation Y cut X propagation (being an Eulerian angle (0**3 degrees, 115 degrees - 128.5 degrees, 0**3 degrees)) more preferably.

[0098]

On the other hand, the frequency temperature characteristic (TCF) of LiTaO₃ substrate of (0 degree, 126 degrees, 0 degree) is -30--40ppm/degree C, and 36-degree rotation Y cut X propagation and an Eulerian angle are not enough as it. In order to improve this frequency temperature characteristic TCF so that it may become within the limits of **20ppm/degree C, 36-degree rotation Y cut X propagation and an Eulerian angle show change of the frequency temperature characteristic at the time of forming IDT which consists of Au and forming SiO₂ film by various thickness further on the LiTaO₃ substrate of (0 degree, 126 degrees, 0 degree), to drawing 19 . In addition, in drawing 19 , 0 shows a theoretical value and x shows an experimental value. Here, the standardization thickness of IDT which consists of Au is $H/\lambda = 0.020$.

[0099]

Formation of SiO₂ film shows that the frequency temperature characteristic is improved so that clearly from drawing 19 . When

thickness H_s/λ by which SiO₂ film was standardized especially is near 0.25, TCF is set to 0 and it turns out that it is desirable.

[0100]

Moreover, numerical analysis of the change of the attenuation coefficient α at the time of changing various thickness of IDT which a cut angle becomes from Au, using LiTaO₃ substrate of two kinds of Eulerian angles, 36 degrees (they are (0 degree, 126 degrees, 0 degree) at an Eulerian angle) and 38 degrees (they are (0 degree, 128 degrees, 0 degree) at an Eulerian angle), as rotation Y cut X propagation LiTaO₃ substrate, and thickness of SiO₂ film was carried out. A result is shown in drawing 20 and drawing 21. In addition, drawing 20 and the thickness value of Au of drawing 21 are H/λ . If the thickness of SiO₂ film is chosen regardless of the thickness of IDT which consists of Au so that clearly from drawing 20 and drawing 21, it turns out that an attenuation coefficient α can be made small. That is, it turns out that an attenuation coefficient α may be made very small in thickness H_s/λ of SiO₂ film when 0.03 to 0.45 and IDT which consists of Au of the range of 0.10–0.35 then LiTaO₃ substrate of one of Eulerian angles, and which thickness more preferably are formed so that clearly from drawing 20 and drawing 21.

[0101]

Furthermore, thin thickness is also known by that the sufficiently big reflection coefficient is obtained compared with aluminum when IDT which consists of Au is used by drawing 17.

Therefore, when thickness H/λ forms IDT which consists of Au of 0.013–0.030 on LiTaO₃ substrate from the result of above-mentioned drawing 16 – drawing 21, it can make an attenuation coefficient α very small, and the range, then the big electromechanical coupling coefficient of 0.03–0.45 are not only obtained in thickness H_s/λ of SiO₂ film, but can obtain sufficient reflection coefficient.

[0102]

In the example mentioned above, a broken line shows the magnitude-of-attenuation-frequency characteristics of the surface acoustic wave equipment 11 of the example which forms IDT which consists of Au of the standardization thickness of $H/\lambda = 0.020$ on the LiTaO₃ substrate of 36 degrees of cut angles (they are (0 degree, 126 degrees, 0 degree) at an Eulerian angle), and comes to form SiO₂ film of standardization thickness $H_s/\lambda = 0.1$ further to drawing 22. Moreover, a continuous line shows the magnitude-of-attenuation frequency characteristics of the structure before forming SiO₂ film in this surface acoustic wave filter for a comparison.

[0103]

Although an electromechanical coupling coefficient becomes small a little from 0.30 by formation of SiO₂ film 0.28 so that clearly from drawing 22 , it turns out that the insertion loss is improved. Therefore, it is proved that the thickness, then the attenuation coefficient α of the range of the above-mentioned specification become small about SiO₂ film so that clearly from drawing 22 .

[0104]

Based on the knowledge mentioned above, the invention-in-this-application person formed IDT which consists of Au whose standardization thickness is 0.02, formed SiO₂ film of still more various thickness on the rotation Y cut X propagation LiTaO₃ substrate of various Eulerian angles, and made 1 port mold surface acoustic wave resonator as an experiment. In this case, standardization thickness of SiO₂ film was set to 0.10, 0.20, and 0.30 and 0.45. Thus, the Q value of the obtained one port each mold surface acoustic wave resonator was measured. A result is shown in drawing 26 .

[0105]

Generally, the steepness of the filter shape which lasts to a decay area from the passband at the time of using as a filter is raised, so that the Q value of a resonator is large. Therefore, when a steep filter is needed, the larger one of Q value is desirable. Regardless of the thickness of SiO₂ film, Q value serves as [a cut angle] max near (0 degree, 138 degrees, 0 degree) by 48-degree rotation Y cut and the Eulerian angle, and it turns out that Q value is comparatively large in the range of 42 degrees - 58 degrees of cut angles (they are (0 degree, 132 degrees - 148 degrees, 0 degree) at an Eulerian angle) so that clearly from drawing 26 .

[0106]

Therefore, LiTaO₃ substrate of 42 degrees - 58 degree rotation Y cut (they are (0 degree, 132 degrees - 148 degrees, 0 degree) at an Eulerian angle) of cut angles is used so that clearly from drawing 26 . By forming at least one IDT which consists of metals with a consistency higher than Au on this LiTaO₃ substrate, and making SiO₂ film into the structure formed on the LiTaO₃ substrate so that IDT might be covered further shows that big Q value can be obtained. Preferably, let a cut angle be 46.5 degrees - 53 degree rotation Y cut (for them to be (0 degree, 136.5 degrees - 143 degrees, 0 degree) at an Eulerian angle) so that clearly from drawing 26 .

[0107]

In addition, an adhesion layer may be formed in the top face of IDT in

this invention. That is, as shown in drawing 27 (a), IDT33 is formed on LiTaO₃ substrate 32, and the adhesion layer 34 may be produced by the top face of IDT33. The adhesion layer 34 is arranged between IDT33 and SiO₂ film 35. The adhesion layer 34 is formed in order to raise the adhesion reinforcement to IDT33 of SiO₂ film 35. As an ingredient which constitutes such an adhesion layer 34, Pd, aluminum, or these alloys are used suitably. Moreover, the adhesion layer 34 may be constituted using other ceramics, such as not only a metal but piezoelectric material, such as ZnO, and Ta₂O₃ or aluminum₂O₃. Rather than aluminum, the adhesion reinforcement of the IDT33 and SiO₂ film 35 with which a consistency consists of a high metal is raised by formation of the adhesion layer 34, and film peeling of SiO₂ film is controlled by it.

[0108]

In order not to have effect on a surface acoustic wave at large, as for the thickness of the adhesion layer 34, it is desirable to consider as about 1% or less of thickness of the wavelength of a surface acoustic wave. Moreover, in drawing 27 (a), although the adhesion layer 34 was formed in the top face of IDT33, as shown in drawing 27 (b), adhesion layer 34A may be formed on LiTaO₃ substrate also at an interface with SiO₂ film 35. As furthermore shown in drawing 27 (c), the adhesion layer 34 may be formed so that not only the top face of IDT33 but a side face may be covered.

[0109]

Moreover, as other configurations which improve the adhesion reinforcement of SiO₂ film, in two or more electrodes containing bus bars other than IDT, or the pad for connection with the exterior, the laminating is carry out on the substrate metal layer which consists these two or more electrodes of the same ingredient as IDT, respectively, and the substrate metal layer, and what consists of an upper metal layer which consists of aluminum or an aluminum alloy may be use. That is, the laminating of the aluminum film may be carried out on the substrate metal layer which consists of the same ingredient as IDT(s) 23a and 23b as an electrode layer which constitutes the reflectors 24a and 24b shown, for example in drawing 15 , and this substrate metal layer. Thus, adhesion reinforcement with SiO₂ film is raised by preparing the upper metal layer which consists of aluminum or an aluminum alloy. Moreover, electrode cost can also be reduced and aluminum wedge bond nature can also be raised further.

[0110]

In addition, the leading-about electrode formed as electrodes other than Above IDT a reflector, a bus bar, and not only the pad for electrode-

connection with the exterior but if needed is mentioned. Moreover, especially as the above-mentioned aluminum alloy, although not limited, an aluminum-Ti alloy, an aluminum-nickel-Cr alloy, etc. are mentioned. [0111]

In addition, when IDT which consists of Au when rotation Y cut X propagation LiTaO₃ substrate of Eulerian angles other than a case of the example of an experiment mentioned above is used is formed, it is confirmed by the invention-in-this-application person etc. that the thickness of SiO₂ film which makes an attenuation coefficient α min exists. That is, an attenuation coefficient α can be made small for thickness H_s/λ of SiO₂ film like the case of the specific range, then the above-mentioned example of an experiment. On the other hand, the Eulerian angle when setting thickness H_s/λ of SiO₂ film to 0.1-0.45 and the relation of α are shown in drawing 28 -36. It also became clear from these drawings that θ of the Eulerian angle from which α becomes the minimum becomes small as the thickness of SiO₂ film became thick. Therefore, even if it is the case where rotation Y cut X propagation LiTaO₃ substrate of other Eulerian angles is used, by forming IDT which consists of Au and choosing the thickness of SiO₂ film in the structure which carried out the laminating of the SiO₂ film, compared with conventional surface acoustic wave equipment, the frequency temperature characteristic TCF is as good as below one half, and can constitute surface acoustic wave equipment with a big reflection coefficient greatly [an electromechanical coupling coefficient]. It is confirmed that it is as a desirable combination of the Eulerian angle of LiTaO₃ substrate which may discover such effectiveness, the electrode layer thickness of IDT which consists of Au, and the thickness of SiO₂ film being shown by the following Table 16 and 17.

[0112]

[Table 16]

θ -角 $(0 \pm 3^\circ, \theta, 0 \pm 3^\circ)$ θ	Au膜厚	SiO ₂ 膜厚
$120.0^\circ \leq \theta < 123.0^\circ$	0.013~0.018	0.15~0.45
$123.0^\circ \leq \theta < 124.5^\circ$	0.013~0.022	0.10~0.40
$124.5^\circ \leq \theta < 125.5^\circ$	0.013~0.025	0.07~0.40
$125.5^\circ \leq \theta < 127.5^\circ$	0.013~0.025	0.06~0.40
$127.5^\circ \leq \theta < 129.0^\circ$	0.013~0.028	0.04~0.40
$129.0^\circ \leq \theta < 130.0^\circ$	0.017~0.030	0.03~0.42
$130.0^\circ \leq \theta < 131.5^\circ$	0.017~0.030	0.03~0.42
$131.5^\circ \leq \theta < 133.0^\circ$	0.018~0.028	0.05~0.33
$133.0^\circ \leq \theta < 135.0^\circ$	0.018~0.030	0.05~0.30
$135.0^\circ \leq \theta \leq 137.0^\circ$	0.019~0.032	0.05~0.25
$137.0^\circ \leq \theta \leq 140.0^\circ$	0.019~0.032	0.05~0.25

[0113]

[Table 17]

θ -角 $(0 \pm 3^\circ, \theta, 0 \pm 3^\circ)$ θ	Au膜厚	SiO ₂ 膜厚
$129.0^\circ \leq \theta < 130.0^\circ$	0.022~0.028	0.04~0.40
$130.0^\circ \leq \theta < 131.5^\circ$	0.022~0.028	0.04~0.40
$131.5^\circ \leq \theta < 133.0^\circ$	0.022~0.028	0.05~0.33
$133.0^\circ \leq \theta < 135.0^\circ$	0.022~0.030	0.05~0.30
$135.0^\circ \leq \theta < 137.0^\circ$	0.022~0.032	0.05~0.25
$137.0^\circ \leq \theta \leq 140.0^\circ$	0.022~0.032	0.05~0.25

[0114]

In addition, -2 degrees - +4 degrees theta of an Eulerian angle may shift from a desired include angle. Since the count result in this application specification is calculated from the thing in which the metal membrane was formed all over the substrate, with actual surface

acoustic wave equipment, an error may generate this gap in the above-mentioned range.

[0115]

After forming IDT which consists of a metal which uses Au as a principal component on rotation Y cut X propagation LiTaO₃ substrate on the occasion of manufacture of the surface acoustic wave equipment concerning this invention, it is desirable to form SiO₂ film of the thickness of the range which performs frequency regulation in the condition and can make an attenuation coefficient α small after an appropriate time. This is explained with reference to drawing 23 and drawing 24 . Drawing 23 shows change of the acoustic velocity of the leakage surface acoustic wave at the time of forming IDT which consists of Au of various thickness, and SiO₂ film of various thickness on 36-degree rotation Y cut X propagation (they being (0-degree, 126-degree, 0 degree) at Eulerian angle) LiTaO₃ substrate. Moreover, drawing 24 shows change of the acoustic velocity of the leakage surface acoustic wave at the time of changing the standardization thickness of SiO₂ film formed on it, when IDT which consists of Au of various thickness is formed on the LiTaO₃ substrate of the same Eulerian angle. If drawing 23 is compared with drawing 24 , change of the acoustic velocity of a surface acoustic wave is far larger than the case where the direction at the time of changing the thickness of Au changes the thickness of SiO₂ film so that clearly. Therefore, it is desirable to perform frequency regulation in advance of formation of SiO₂ film, for example, after forming IDT which consists of Au by laser etching, ion etching, etc., it is desirable to perform frequency regulation. Especially, preferably, if the range of the standardization thickness of Au is 0.015-0.03, change of the acoustic velocity by SiO₂ film becomes small, and the frequency drift by dispersion in SiO₂ film can be made small.

[0116]

In addition, -2 degrees - +4 degrees theta of an Eulerian angle may shift from a desired include angle. Since the count result in this application specification is calculated from the thing in which the metal membrane was formed all over the substrate, with actual surface acoustic wave equipment, an error may generate this gap in the above-mentioned range.

[0117]

Moreover, although ϕ and ψ of an Eulerian angle varied from 0 degree at the time of manufacture, the property as a 0-degree thing that a property is almost the same was acquired.
[electrode material is example [of Ag]].

The surface acoustic wave equipment of this example is the same as the surface acoustic wave equipment 21 shown in drawing 15 mentioned above. But IDT(s) 23a and 23b are constituted from this example by Ag.

[0118]

When IDT(s) 23a and 23b consist of Ag so that it may mention later, as for thickness H/λ standardized on the wavelength of the surface acoustic wave of IDT(s) 23a and 23b, 0.01-0.08 are desirable.

[0119]

With the surface acoustic wave equipment which this invention requires, as mentioned above, IDT(s) 23a and 23b are constituted by Ag on LiTaO₃ substrate 22, and this electrode layer thickness of IDT(s) 23a and 23b can be made thin. Since LiTaO₃ substrate of an Eulerian angle is used, an attenuation coefficient can be sharply made small, and low loss-ization is attained. Moreover, the good frequency temperature characteristic is realized by formation of SiO₂ film 25. This is explained based on the concrete example of an experiment.

[0120]

The leakage surface acoustic wave (LSAW) other than a Rayleigh wave is shown in the surface acoustic wave transmitted in LiTaO₃ substrate. A leakage surface acoustic wave is spread emitting energy in a substrate, although the electromechanical coupling coefficient of acoustic velocity is large early compared with a Rayleigh wave. Therefore, a leakage surface acoustic wave has an attenuation coefficient leading to a propagation loss.

[0121]

Drawing 36 indicates relation with an electromechanical coupling coefficient K_{saw} to be standardization thickness H/λ of Ag film at the time of forming IDT which consists of Ag on 36-degree rotation Y cut X propagation LiTaO₃ substrate (they being (0 degree, 126 degrees, 0 degree) at an Eulerian angle). In addition, λ shall show the wavelength in the center frequency of surface acoustic wave equipment.

[0122]

It turns out that thickness H/λ of Ag film becomes [an electromechanical coupling coefficient K_{saw}] 1.5 or more times in the range of 0.01-0.08 compared with the case ($H/\lambda = 0$) where Ag film is not formed so that clearly from drawing 36 . Moreover, compared with the case where Ag film is not formed for the thickness of Ag film in $H/\lambda = 0.02-0.06$, it turns out that an electromechanical coupling coefficient K_{saw} serves as a value of 1.7 times or more, and thickness H/λ of Ag film serves as a value of 1.8 times or more in case Ag film is not formed in 0.03-0.05.

[0123]

If standardization thickness H/λ of Ag film exceeds 0.08, production of IDT which consists of Ag film will become difficult. Therefore, as for the thickness of IDT which can obtain a big electromechanical coupling coefficient, and consists of Ag film since production of IDT is easy, it is desirable that it is the range of 0.01-0.08, and it considers as the range of 0.03-0.05 preferably [it is more desirable and] to 0.02 to 0.06, and a pan.

[0124]

Next, change of the frequency temperature coefficient TCF at the time of forming SiO₂ film on LiTaO₃ substrate is shown in drawing 37 . drawing 37 -- an Eulerian angle (0 degree, 113 degrees, 0 degree) -- and (0 degree, 126 degrees, 0 degree) (0 degree, 129 degrees, 0 degree) shows the relation between standardization thickness H_s/λ of SiO₂ film in case SiO₂ film is formed on three kinds of LiTaO₃ substrates, and TCF. In addition, the electrode is not formed here.

[0125]

When theta is any which are 113 degrees, 126 degrees, and 129 degrees so that clearly from drawing 37 , it turns out that standardization thickness H_s/λ of SiO₂ film serves as range whose TCF is -20-+20ppm/degree C in the range of 0.15-0.45. But in order for membrane formation of SiO₂ film to take time amount, as for thickness H_s/λ of SiO₂ film, 0.15-0.40 are desirable.

[0126]

Although it was known that TCF(s), such as a Rayleigh wave, will be improved by forming SiO₂ film on LiTaO₃ substrate, the electrode which consists of Ag is formed on LiTaO₃ substrate, and there is no report in which it actually experimented in consideration of the attenuation coefficient of the thickness of the electrode which consists of Ag, the thickness of SiO₂, an Eulerian angle, and a leakage elastic wave in the structure which carried out the laminating of the SiO₂ film further.

[0127]

Drawing 38 shows change of the attenuation coefficient alpha when the electrode with which standardization thickness H/λ consists of 0.10 or less Ag, and standardization thickness H_s/λ form SiO₂ film of 0-0.5 on the LiTaO₃ substrate of an Eulerian angle (0 degree, 120 degrees, 0 degree). When thickness H_s/λ of SiO₂ film is [thickness H/λ of 0.2 to 0.40 and Ag film] 0.01-0.10 so that clearly from drawing 38 , it turns out that the attenuation coefficient alpha is small.

[0128]

On the other hand, on the LiTaO₃ substrate of the Eulerian angle of (0

degree, 140 degrees, 0 degree), standardization thickness H/λ forms Ag film of 0-0.10, and drawing 39 shows change of the attenuation coefficient α when standardization thickness H_s/λ forms SiO₂ film of 0-0.5 further.

[0129]

Though the thickness of Ag film changes the thickness of SiO₂ film as mentioned above or less in 0.06 when LiTaO₃ $\theta = 140^\circ$ substrate is used by the Eulerian angle so that clearly from drawing 39, it turns out that an attenuation coefficient α is large.

[0130]

That is, in order to realize good TCF, a big electromechanical coupling coefficient, and a small attenuation coefficient, it turns out that it is necessary to combine the cut angle of LiTaO₃ substrate, i.e., an Eulerian angle, the thickness of SiO₂ film, and the thickness of the electrode which consists of Ag, respectively so that it may be the optimal.

[0131]

Standardization thickness H_s/λ of SiO₂ film is 0.1, 0.15, 0.2, 0.25, 0.3, 0.35, and 0.4 or 0.45, and drawing 40 - drawing 47 show θ when standardization thickness H/λ forms 0.1 or less Ag film on LiTaO₃ substrate, and relation with an attenuation coefficient α , respectively.

[0132]

If the thickness of SiO₂ film and θ of an Eulerian angle are chosen so that it may become one of the combination shown in the following table 18 when thickness H/λ of Ag film is set to 0.01-0.08 so that clearly from drawing 40 - drawing 47, the frequency temperature characteristic TCF is good, and an electromechanical coupling coefficient is large, and it turns out that an attenuation coefficient α can be controlled effectively. Desirably, a much more good property can be acquired by choosing the more desirable Eulerian angle on the right-hand side of the following table 18.

[0133]

[Table 18]

Ag 膜厚 H/λ : 0.01~0.08 のとき

SiO ₂ 膜厚	LiTaO ₃ のオイラー角	より好ましいオイラー角
0.15~0.18	0±3, 117~137, 0±3	0±3, 120~135, 0±3
0.18~0.23	0±3, 117~136, 0±3	0±3, 118~133, 0±3
0.23~0.28	0±3, 115~135, 0±3	0±3, 117~133, 0±3
0.28~0.33	0±3, 113~133, 0±3	0±3, 115~132, 0±3
0.33~0.38	0±3, 113~135, 0±3	0±3, 115~133, 0±3
0.38~0.40	0±3, 113~132, 0±3	0±3, 115~130, 0±3

[0134]

Moreover, if it is more preferably chosen so that the thickness of SiO₂ film and theta of an Eulerian angle may become one of the combination shown in the following table 19 when the standardization thickness of Ag film is 0.02-0.06, a much more good property can be acquired much more desirable still more desirably by choosing the more desirable Eulerian angle on the right-hand side of the following table 19.

[0135]

[Table 19]

Ag 膜厚 H/λ : 0.02~0.06 のとき

SiO ₂ 膜厚	LiTaO ₃ のオイラー角	より好ましいオイラー角
0.15~0.18	0±3, 120~133, 0±3	0±3, 122~130, 0±3
0.18~0.23	0±3, 120~137, 0±3	0±3, 122~136, 0±3
0.23~0.28	0±3, 120~135, 0±3	0±3, 122~133, 0±3
0.28~0.33	0±3, 118~135, 0±3	0±3, 120~133, 0±3
0.33~0.38	0±3, 115~133, 0±3	0±3, 117~130, 0±3
0.38~0.40	0±3, 113~130, 0±3	0±3, 115~128, 0±3

[0136]

If it is chosen still more preferably so that the thickness of SiO₂ film and theta of an Eulerian angle may become one of the combination shown in the following table 20 when the standardization thickness of Ag film is 0.03-0.05, a much more good property can be acquired. Also in this case, a property can be further improved by choosing a desirable Eulerian angle rather than it is shown in the right-hand side of the

following table 20.

[0137]

[Table 20]

Ag 膜厚 H/λ : 0.03 ~ 0.05 のとき

SiO ₂ 膜厚	LiTaO ₃ のオイラー角	より好ましいオイラー角
0.15~0.18	0±3, 122~142, 0±3	0±3, 123~140, 0±3
0.18~0.23	0±3, 120~140, 0±3	0±3, 122~137, 0±3
0.23~0.28	0±3, 117~138, 0±3	0±3, 120~135, 0±3
0.28~0.33	0±3, 116~136, 0±3	0±3, 118~134, 0±3
0.33~0.38	0±3, 114~135, 0±3	0±3, 117~133, 0±3
0.38~0.40	0±3, 113~130, 0±3	0±3, 115~128, 0±3

[0138]

In addition, by this invention, although IDT may consist of only Ag, as long as Ag is made into a subject, it may consist of layered products of Ag alloy, or Ag and other metals. In IDT which makes Ag a subject, 80% of the weight or more of the whole IDT should just be Ag. Therefore, aluminum thin film and Ti thin film may be formed in the substrate of Ag, and 80 % of the weight or more out of the sum total of the thin film of a substrate and Ag should just consist of Ag also in this case.

[0139]

In the above-mentioned experiment, although LiTaO₃ substrate of an Eulerian angle (0 degree, theta, 0 degree) was used, in the Eulerian angle of a substrate ingredient, 0°-3-degree dispersion usually occurs in phi and psi. Within the limits (0°-3 degrees, 113 degrees - 142 degrees, 0°-3 degrees) it is such dispersion, the effectiveness of this invention is acquired also in LiTaO₃ substrate.

[0140]

In addition, -2 degrees - +4 degrees theta of an Eulerian angle may shift from a desired include angle. Since the count result in this application specification is calculated from the thing in which the metal membrane was formed all over the substrate, with actual surface acoustic wave equipment, an error may generate this gap in the above-mentioned range.

[0141]

[The example at the time of using Cu as an electrode material]

If it removed having formed the electrode by Cu, the surface acoustic wave equipment shown in drawing 15 like the case where Au is used was

constituted. Since the electrode is constituted by Cu with a high consistency compared with aluminum, an electromechanical coupling coefficient and a reflection coefficient can be raised.

[0142]

Drawing 58 is drawing showing the reflection factor per electrode layer of Cu electrode in case the standardization thickness of SiO₂ film is 0.20, and aluminum electrode, and relation with electrode layer thickness.

Since the reflection factor per electrode finger is raised when the electrode which consists of Cu is used compared with the electrode which consists of aluminum used conventionally, as shown in drawing 58, the number of the electrode finger in a reflector can also be reduced. Therefore, the miniaturization of a reflector, as a result the miniaturization of surface acoustic wave equipment can be attained.

[0143]

As for thickness H/λ standardized on the wavelength of the surface acoustic wave of IDT(s) 23a and 23b, 0.01-0.08 are desirable so that it may mention later.

Drawing 48 shows change of the attenuation coefficient α when the electrode with which standardization thickness H/λ consists of 0.10 or less Cu, and standardization thickness H_s/λ from SiO₂ film of 0-0.5 on the LiTaO₃ substrate of an Eulerian angle (0 degree, 120 degrees, 0 degree). When thickness H_s/λ of SiO₂ film is [thickness H/λ of 0.2 to 0.40 and Cu film] 0.01-0.10 so that clearly from drawing 48, it turns out that the attenuation coefficient α is small.

[0144]

On the other hand, on the LiTaO₃ substrate of the Eulerian angle of (0 degree, 135 degrees, 0 degree), standardization thickness H/λ forms Cu film of 0-0.10, and drawing 49 shows change of the attenuation coefficient α when standardization thickness H_s/λ forms SiO₂ film of 0-0.5 further.

[0145]

Though the thickness of Cu film and the thickness of SiO₂ film are changed as mentioned above when LiTaO₃ $\theta = 135$ -degree substrate is used so that clearly from drawing 49, it turns out that an attenuation coefficient α is large.

[0146]

That is, in order to realize good TCF, a big electromechanical coupling coefficient, and a small attenuation coefficient, it turns out that it is necessary to combine the cut angle of LiTaO₃ substrate, i.e., an Eulerian angle, the thickness of SiO₂ film, and the thickness of the

electrode which consists of Cu, respectively so that it may be the optimal.

[0147]

Standardization thickness H_s/λ of SiO₂ film is 0.1, 0.15, 0.2, 0.25, 0.3, 0.35, and 0.4 or 0.45, and drawing 50 - drawing 57 show theta when standardization thickness H/λ forms 0.08 or less Cu film on LiTaO₃ substrate, and relation with an attenuation coefficient alpha, respectively.

[0148]

If the thickness of SiO₂ film and theta of an Eulerian angle are chosen as shown in the following table 21 when thickness H/λ of Cu film is set to 0.01-0.08 so that clearly from drawing 50 - drawing 57, it considers as within the limits whose frequency temperature characteristic TCF is ± 20 ppm/degree C, and it is good, and an electromechanical coupling coefficient is large, and it turns out that an attenuation coefficient alpha can be controlled effectively. Desirably, a much more good property can be acquired by choosing the more desirable Eulerian angle on the right-hand side of the following table 21.

[0149]

[Table 21]

SiO ₂ 膜厚	LiTaO ₃ のオイラー角	より好ましくは
0.15~0.18	(0 ± 3 , 117~137, 0 ± 3)	(0 ± 3 , 120~135, 0 ± 3)
0.18~0.23	(0 ± 3 , 117~136, 0 ± 3)	(0 ± 3 , 118~133, 0 ± 3)
0.23~0.28	(0 ± 3 , 115~135, 0 ± 3)	(0 ± 3 , 117~133, 0 ± 3)
0.28~0.33	(0 ± 3 , 113~133, 0 ± 3)	(0 ± 3 , 115~132, 0 ± 3)
0.33~0.38	(0 ± 3 , 113~135, 0 ± 3)	(0 ± 3 , 115~133, 0 ± 3)
0.38~0.4	(0 ± 3 , 113~132, 0 ± 3)	(0 ± 3 , 115~130, 0 ± 3)

[0150]

Moreover, when theta of an Eulerian angle becomes 125 degrees or less so that it may be guessed from drawing 25 about Au, it turns out that an electromechanical coupling coefficient K_{saw} becomes remarkably large. Therefore, it turns out that the combination of the standardization thickness H_s/λ of SiO₂ film and the Eulerian angle which are shown in the following table 22 is desirable more preferably.

[0151]

[Table 22]

SiO ₂ 膜厚	LiTaO ₃ のオイラー角
0.15~0.18	(0±3, 117~125, 0±3)
0.18~0.23	(0±3, 117~125, 0±3)
0.23~0.28	(0±3, 115~125, 0±3)
0.28~0.33	(0±3, 113~125, 0±3)
0.33~0.38	(0±3, 113~125, 0±3)
0.38~0.40	(0±3, 113~125, 0±3)

[0152]

Furthermore, the result of having searched for the Eulerian angle from which an attenuation coefficient serves as 0 or min, i.e., thetamin, from the result shown in drawing 48 - drawing 56 from standardization thickness Hs/lambda of SiO₂ film and standardization thickness H/lambda of Cu film is shown in drawing 59 .

[0153]

When standardization thickness H/lambda of Cu film approximates each curve shown in drawing 59 in 0, 0.02, 0.04, and 0.06 and 0.08 by the cubic polynomial, following formula A-E is obtained.

(a) At the time of $0 < H/\lambda \leq 0.01$

thetamin = $-139.713xHs^3 + 43.07132xHs^2$

- $20.568011xHs + 125.8314$ -- Formula A

(b) At the time of $0.01 < H/\lambda \leq 0.03$

thetamin = $-139.660xHs^3 + 46.02985xHs^2$

- $21.141500xHs + 127.4181$ -- At the time of formula B(c) $0.03 < H/\lambda \leq 0.05$

thetamin = $-139.607xHs^3 + 48.98838xHs^2$

- $21.714900xHs + 129.0048$ -- At the time of formula C(d) $0.05 < H/\lambda \leq 0.07$

thetamin = $-112.068xHs^3 + 39.60355xHs^2$

- $21.186000xHs + 129.9397$ -- At the time of formula D(e) $0.07 < H/\lambda \leq 0.09$

thetamin = $-126.954xHs^3 + 67.40488xHs^2$

- $29.432000xHs + 131.5686$ -- Formula E

Therefore, preferably, although it is desirable to be referred to as thetamin shown by the formula A mentioned above - Formula E as for theta of an Eulerian angle ($0 \leq \theta \leq 3$ degrees, theta, $0 \leq \theta \leq 3$ degrees), if it is thetamin-2 degree $< \theta \leq$ thetamin+2 degree, it can make an attenuation coefficient small effectively.

[0154]

In addition, although IDT may consist of only Cu(s), as long as Cu is made into a subject, it may be constituted from this invention by the layered product of Cu alloy, or Cu and other metals. If mean density of an electrode is set to ρ (average) in IDT which makes Cu a subject $\rho(\text{Cu}) \times 0.7 \leq \rho(\text{average}) \leq \rho(\text{Cu}) \times 1.3$

namely

$6.25 \text{ g/cm}^3 \leq \rho(\text{average}) \leq 11.6 \text{ g/cm}^3$

What is necessary is just satisfied. In addition, the laminating of the electrode which consists of metals, such as W, Ta, Au, Pt, Ag, or Cr with a larger consistency than aluminum, may be carried out so that ρ (average) of the whole electrode may become the above-mentioned range on Cu or in the bottom. Also in such a case, the same effectiveness as the case of Cu electrode monolayer is acquired.

[0155]

In addition, -2° to $+4^\circ$ of an Eulerian angle may shift from a desired include angle. Since the count result in this application specification is calculated from the thing in which the metal membrane was formed all over the substrate, with actual surface acoustic wave equipment, an error may generate this gap in the above-mentioned range.

[0156]

Moreover, although 0° to 3° of an Eulerian angle varied from 0° at the time of manufacture, the property as a 0° -degree thing that a property is almost the same was acquired.

[The example using the tungsten as an electrode material]

The surface acoustic wave equipment shown in drawing 15 was constituted like the example mentioned above. However, the tungsten constituted IDT and a reflector. Standardization thickness H/λ of IDT was taken as the range of 0.0025–0.06.

[0157]

Moreover, as LiTaO₃ substrate, LiTaO₃ substrate of (0° , 112° , 138° , 0°) was used by 22° to 48° rotation Y cut X propagation and the Eulerian angle.

IDT(s) 3a and 3b which serve as the piezo-electric substrate 22 which consists of 22° to 48° rotation Y cut X propagation LiTaO₃ from the tungsten which is $H/\lambda = 0.0025$ – 0.06 as mentioned above in this example, and $H_s/\lambda =$ since SiO₂ film 4 in the range of 0.10–0.40 is used, the frequency temperature coefficient TCF is small and a propagation loss can offer small surface acoustic wave equipment greatly [an electromechanical coupling coefficient K_{saw}]. This is explained based on the following concrete examples of an experiment.

[0158]

drawing 60 and drawing 61 -- an Eulerian angle (0 degree, 120 degrees, 0 degree) and every of (0 degree, 140 degrees, 0 degree) -- it is drawing showing the attenuation coefficient at the time of forming IDT which consists of a tungsten of various thickness, and SiO₂ film of various thickness on LiTaO₃ substrate.

[0159]

At $\theta = 120$ degrees, it turns out that standardization thickness H/λ of the electrode with which thickness H_s/λ of SiO₂ consists of 0.1-0.40, and a tungsten has a small attenuation coefficient in the range of 0.0-0.10 so that clearly from drawing 60 . On the other hand, at $\theta = 140$ degrees, it turns out that the attenuation coefficient is [standardization thickness H/λ of the electrode which consists of a tungsten] large regardless of the thickness of SiO₂ film in 0.0-0.10 so that clearly from drawing 61 .

[0160]

That is, in order to make TCF small with ~ 20 ppm/degree C, and to obtain a big electromechanical coupling coefficient and to make an attenuation coefficient small, it turns out that three conditions of the thickness of the electrode which consists of the thickness and the tungsten of the Eulerian angle of LiTaO₃ substrate and SiO₂ film must be taken into consideration.

[0161]

Drawing 62 - drawing 65 show the relation of the θ (degree) and the attenuation coefficient at the time of changing standardization thickness H/λ of the electrode layer which consists of standardization thickness H_s/λ and the tungsten of SiO₂ film.

[0162]

In 0.012-0.053, and 0.015-0.042, it becomes as standardization thickness H/λ of the electrode which consists of a tungsten shows the thickness of SiO₂ film, and the relation with optimal θ in the following Table 23 and 24, so that clearly from drawing 62 - drawing 65 . In addition, this -2 degrees - about +4 degrees optimal θ may vary by dispersion in the electrode digit of a wolfram electrode, or dispersion of a single crystal substrate. In addition, the thickness which is not illustrated is based on proportional distribution among drawing.

[0163]

[Table 23]

電極の $H/\lambda = 0.012 \sim 0.053$ のとき

SiO ₂ の規格化膜厚	LiTaO ₃ のツイ-角	より好ましくは
0.1~0.15	(0±3, 114.2~138.0±3)	(0±3, 117.7~134.0±3)
0.15~0.2	(0±3, 113~137.8, 0±3)	(0±3, 117~133.5, 0±3)
0.2~0.3	(0±3, 113~137.5, 0±3)	(0±3, 116.5~133, 0±3)
0.3~0.35	(0±3, 112.7~137, 0±3)	(0±3, 116.5~133, 0±3)
0.35~0.4	(0±3, 112.5~136, 0±3)	(0±3, 116.5~132.3, 0±3)

[0164]

[Table 24]

電極の $H/\lambda = 0.015 \sim 0.042$ のとき

SiO ₂ の規格化膜厚	LiTaO ₃ のツイ-角	より好ましくは
0.1~0.15	(0±3, 114.3~138, 0±3)	(0±3, 117.7~133.5, 0±3)
0.15~0.2	(0±3, 113~137.5, 0±3)	(0±3, 117.7~133.5, 0±3)
0.2~0.3	(0±3, 112.5~137, 0±3)	(0±3, 117~132.5, 0±3)
0.3~0.35	(0±3, 112.2~136.5, 0±3)	(0±3, 116.8~132.5, 0±3)
0.35~0.4	(0±3, 112~135.3, 0±3)	(0±3, 116~131.5, 0±3)

[0165]

Namely, in order that thickness H/λ of the electrode which consists of a tungsten may improve the frequency temperature characteristic TCF in the case of 0.012-0.053 so that it may become within the limits of **20ppm/degree C so that clearly from Table 23 and 24 When thickness H/λ of SiO₂ film is made into the range of 0.1-0.4, it turns out that theta in the Eulerian angle of LiTaO₃ should just choose the range of 20 degrees - 50 degrees, and the Eulerian angle more preferably shown in Table 23 in the range of 112 degrees - 138 degrees, i. e., an angle of rotation.

[0166]

In order similarly for the standardization thickness of the electrode which consists of tungsten film to be 0.015-0.042, and to improve the frequency temperature characteristic TCF so that it may become within the limits of **20ppm/degree C so that clearly from Table 24 When thickness H/λ of SiO₂ film is made into the range of 0.1-0.4, it is good and, as for the Eulerian angle of LiTaO₃ substrate, it turns out

that what is necessary is the range of 112 degrees - 138 degrees, then just to choose the Eulerian angle of Table 24 according to the thickness of SiO₂ film more preferably.

[0167]

Here, as for the range of "the Eulerian angle of LiTaO₃" in Table 23 and 24, an attenuation coefficient specifies 0.05 or less range. Moreover, an attenuation coefficient specifies the range the Eulerian angle of LiTaO₃ in Table 23 and 24 "is more desirable in the range" or less to 0.025. Moreover, it converts and asks for thickness H_s/λ of SiO₂ film in case the standardization thickness of the electrode layer which consists of a tungsten is 0.012, 0.015, 0.042, and 0.053, and the relation of an Eulerian angle from the standardization thickness of the electrode layer which consists of a tungsten shown in drawing 62 R> 2 - drawing 65, and they are calculating the thickness of SiO₂ film of Table 23 and 24, and the value of an Eulerian angle by it.

[0168]

After forming IDT which consists of a metal which uses a tungsten as a principal component on rotation Y cut X propagation LiTaO₃ substrate on the occasion of manufacture of the surface acoustic wave equipment concerning this invention, it is desirable to form SiO₂ film of the thickness of the range which performs frequency regulation in the condition and can make an attenuation coefficient α small after an appropriate time. This is explained with reference to drawing 66 and drawing 67. Drawing 66 shows change of the acoustic velocity of the leakage surface acoustic wave at the time of forming SiO₂ film of IDT which consists of a tungsten of various thickness H/λ , and various thickness H_s/λ on the rotation Y cut X propagation LiTaO₃ substrate of an Eulerian angle (0 degree, 126 degrees, 0 degree). Moreover, drawing 67 shows change of the acoustic velocity of the leakage surface acoustic wave at the time of changing standardization thickness H_s/λ of SiO₂ film formed on it, when IDT which consists of a tungsten of various thickness H/λ is formed on the LiTaO₃ substrate of the same Eulerian angle. If drawing 66 is compared with drawing 67, change of the acoustic velocity of a surface acoustic wave is far larger than the case where the direction at the time of changing the thickness of a tungsten changes the thickness of SiO₂ film so that clearly.

Therefore, it is desirable to perform frequency regulation in advance of formation of SiO₂ film, for example, after forming IDT which consists of a tungsten (W) by laser etching, ion etching, etc., it is desirable to perform frequency regulation.

[0169]

In addition, IDT which this invention becomes from 22 degrees - 48 degree rotation Y cut X propagation, the piezo-electric substrate which consists of LiTaO₃ of (0 degree, 112 degrees - 138 degrees, 0 degree) by the Eulerian angle, and the tungsten which is $H/\lambda = 0.0025-0.06$ as mentioned above and $H_s/\lambda =$ it is not characterized by having SiO₂ film which is 0.10-0.40, and is not limited [therefore] especially about a number, structure, etc. of IDT. That is, this invention is applicable to various surface acoustic wave resonators, a surface acoustic wave filter, etc., as long as not only the surface acoustic wave equipment shown in drawing 15 but the above-mentioned conditions are fulfilled.

[0170]

In addition, -2 degrees - +4 degrees theta of an Eulerian angle may shift from a desired include angle. Since the count result in this application specification is calculated from the thing in which the metal membrane was formed all over the substrate, with actual surface acoustic wave equipment, an error may generate this gap in the above-mentioned range.

Moreover, although ϕ and ψ of an Eulerian angle varied from 0 degree at the time of manufacture, the property as a 0-degree thing that a property is almost the same was acquired.

[0171]

[The example at the time of using Ta as an electrode material]

The surface acoustic wave equipment shown in drawing 15 was constituted. However, using the substrate which consists of LiTaO₃ of (0 degree, 104 degrees - 148 degrees, 0 degree) by 14 degrees - 58 degree rotation Y cut X propagation and the Eulerian angle as a piezoelectric substrate 22, the tantalum (Ta) constituted IDT and the standardization thickness H/λ was taken as the range of 0.004-0.055.

[0172]

The piezo-electric substrate 2 which consists of LiTaO₃ of (0 degree, 104 degrees - 148 degrees, 0 degree) as mentioned above in this example according to 14 degrees - 58 degree rotation Y cut X propagation and an Eulerian angle, IDT(s) 3a and 3b which consist of a tantalum which is $H/\lambda = 0.004-0.055$, and $H_s/\lambda =$ Since SiO₂ film 4 in the range of 0.10-0.40 is used, The frequency temperature coefficient TCF is small and a propagation loss can offer small surface acoustic wave equipment greatly [an electromechanical coupling coefficient K_{saw}]. This is explained based on the following concrete examples of an experiment.

[0173]

drawing 68 and drawing 69 -- an Eulerian angle (0 degree, 120 degrees, 0

degree) and every of (0 degree, 140 degrees, 0 degree) -- it is drawing showing the attenuation coefficient at the time of forming IDT which consists of a tantalum of various thickness, and SiO₂ film of various thickness on LiTaO₃ substrate.

[0174]

At $\theta = 120$ degrees, it turns out that standardization thickness H/λ of the electrode with which thickness H_s/λ of SiO₂ consists of 0.1-0.40, and a tantalum has a small attenuation coefficient in the range of 0.0-0.10 so that clearly from drawing 68 . On the other hand, at $\theta = 140$ degrees, it turns out that the attenuation coefficient is [standardization thickness H/λ of the electrode which consists of a tantalum] large regardless of the thickness of SiO₂ film in 0.0-0.06 so that clearly from drawing 69 .

[0175]

That is, in order to make the absolute value of TCF small, and to obtain a big electromechanical coupling coefficient and to make an attenuation coefficient small, it turns out that three conditions of the thickness of the electrode which consists of the thickness and the tantalum of the Eulerian angle of LiTaO₃ substrate and SiO₂ film must be taken into consideration.

[0176]

Drawing 70 - drawing 73 show the relation of the θ and the attenuation coefficient at the time of changing standardization thickness H/λ of the electrode layer which consists of standardization thickness H_s/λ and the tantalum of SiO₂ film. In 0.01-0.055, and 0.016-0.045, it becomes as standardization thickness H/λ of the electrode which consists of a tantalum shows the thickness of SiO₂ film, and the relation with optimal θ in the following Table 25 and 26, so that clearly from drawing 70 - drawing 73 . In addition, this -2 degrees - about +4 degrees optimal θ may vary by dispersion in the electrode digit of a tantalum electrode, or dispersion of a single crystal substrate.

[0177]

[Table 25]

電極の $H/\lambda = 0.01 \sim 0.055$ のとき

SiO ₂ の規格化膜厚	LiTaO ₃ のオイラ-角	より好ましくは
0.1~0.15	(0±3, 110.5~148, 0±3)	(0±3, 116~143, 0±3)
0.15~0.2	(0±3, 108~147.5, 0±3)	(0±3, 115~141.5, 0±3)
0.2~0.3	(0±3, 105~148, 0±3)	(0±3, 111~139, 0±3)
0.3~0.35	(0±3, 104.5~148, 0±3)	(0±3, 111~139, 0±3)
0.35~0.4	(0±3, 104~145, 0±3)	(0±3, 110~138.5, 0±3)

[0178]

[Table 26]

電極の $H/\lambda = 0.016 \sim 0.045$ のとき

SiO ₂ の規格化膜厚	LiTaO ₃ のオイラ-角	より好ましくは
0.1~0.15	(0±3, 113~144, 0±3)	(0±3, 118~140, 0±3)
0.15~0.2	(0±3, 111~144, 0±3)	(0±3, 117~139.5, 0±3)
0.2~0.3	(0±3, 108~144, 0±3)	(0±3, 113~139, 0±3)
0.3~0.35	(0±3, 107.5~143, 0±3)	(0±3, 112.5~137, 0±3)
0.35~0.4	(0±3, 107~140.5, 0±3)	(0±3, 112~135.5, 0±3)

[0179]

Namely, in order that thickness H/λ of the electrode which consists of a tantalum may improve in the case of 0.01-0.055 so that the frequency temperature characteristic TCF may be made into within the limits of $\pm 20\text{ppm/degree C}$ so that clearly from Table 25 and 26 When standardization thickness of SiO₂ film is made into the range of 0.1-0.4, theta in the Eulerian angle of LiTaO₃ It turns out in the range of 104 degrees - 148 degrees, i.e., an angle of rotation, that what is necessary is just to choose the range of 14 degrees - 58 degrees, and the Eulerian angle more preferably shown in Table 25 according to thickness H/λ of SiO₂.

[0180]

Similarly, the standardization thickness of the electrode which consists of tantalum film is 0.016-0.045, and in order to improve the frequency temperature characteristic TCF, when thickness H/λ of SiO₂ film is

made into the range of 0.1-0.4, it is good and, as for the Eulerian angle of LiTaO₃ substrate, it turns out that what is necessary is the range of 107 degrees - 144 degrees, then just to choose the Eulerian angle of Table 26 according to thickness H_s/λ of SiO₂ film more preferably, so that clearly from Table 26.

[0181]

As for the range of the Eulerian angle of LiTaO₃, an attenuation coefficient specifies 0.05 or less range. Moreover, an attenuation coefficient specifies the more desirable range of the Eulerian angle of LiTaO₃ in Table 25 and 26 or less to 0.025. Moreover, it converts and asks for thickness H_s/λ of SiO₂ film in case the standardization thickness of the electrode layer which consists of a tantalum is 0.012, 0.015, 0.042, and 0.053, and the relation of an Eulerian angle from the standardization thickness of the electrode layer which consists of a tantalum shown in drawing 70 - drawing 73, and they are calculating thickness H_s/λ of SiO₂ film of Table 25 and 26, and the value of an Eulerian angle.

[0182]

After forming IDT which consists of a metal which uses a tantalum as a principal component on rotation Y cut X propagation LiTaO₃ substrate on the occasion of manufacture of the surface acoustic wave equipment concerning this invention, it is desirable to form SiO₂ film of the thickness of the range which performs frequency regulation in the condition and can make an attenuation coefficient α small after an appropriate time. This is explained with reference to drawing 74 and drawing 75. Drawing 74 shows the relation between standardization thickness H/λ of a tantalum at the time of forming IDT and SiO₂ film which consists of a tantalum on the rotation Y cut X propagation LiTaO₃ substrate of an Eulerian angle (0 degree, 126 degrees, 0 degree), standardization thickness H_s/λ of SiO₂ film, and the acoustic velocity of a leakage surface acoustic wave. Moreover, drawing 75 shows change of the acoustic velocity of the leakage surface acoustic wave at the time of changing the standardization thickness of SiO₂ film which forms IDT which consists of a tantalum of various thickness on the LiTaO₃ substrate of the same Eulerian angle, and is formed on it. If drawing 74 $R > 4$ is compared with drawing 75, change of the acoustic velocity of a surface acoustic wave is far larger than the case where the direction at the time of changing the thickness of a tantalum changes the thickness of SiO₂ film so that clearly. Therefore, it is desirable to perform frequency regulation in advance of formation of SiO₂ film, for example, after forming IDT which consists of a tantalum

by laser etching, ion etching, etc., it is desirable to perform frequency regulation.

[0183]

In addition, IDT which this invention becomes from 14 degrees - 58 degree rotation Y cut X propagation, the piezo-electric substrate which consists of LiTaO₃ of (0 degree, 104 degrees - 148 degrees, 0 degree) by the Eulerian angle, and the tantalum which is $H/\lambda = 0.004-0.055$ as mentioned above and $H_s/\lambda =$ it is not characterized by having SiO₂ film which is 0.10-0.40, and is not limited [therefore] especially about a number, structure, etc. of IDT. That is, this invention is applicable to various surface acoustic wave resonators, a surface acoustic wave filter, etc., as long as not only the surface acoustic wave equipment shown in drawing 15 but the above-mentioned conditions are fulfilled.

[0184]

In addition, -2 degrees - +4 degrees theta of an Eulerian angle may shift from a desired include angle. Since the count result in this application specification is calculated from the thing in which the metal membrane was formed all over the substrate, with actual surface acoustic wave equipment, an error may generate this gap in the above-mentioned range.

Moreover, although ϕ and ψ of an Eulerian angle varied from 0 degree at the time of manufacture, the property as a 0-degree thing that a property is almost the same was acquired.

[0185]

[The example using platinum as an electrode material]

The piezo-electric substrate which consists of LiTaO₃ substrate of (0 degree, 90 degrees - 169 degrees, 0 degree) the surface acoustic wave equipment shown in drawing 15 by 0 degree - 79 degree rotation Y cut X propagation and the Eulerian angle, and $H/\lambda =$ it constituted using IDT which consists of platinum which is 0.005-0.054. Other points are the same as the example mentioned above.

[0186]

Also in this example, since it has the above-mentioned configuration, the frequency temperature coefficient TCF is small and a propagation loss can offer small surface acoustic wave equipment greatly [an electromechanical coupling coefficient K_{saw}]. This is explained based on the following concrete examples of an experiment.

[0187]

drawing 76 and drawing 77 -- an Eulerian angle (0 degree, 125 degrees, 0 degree) and every of (0 degree, 140 degrees, 0 degree) -- it is drawing

showing the attenuation coefficient at the time of forming IDT which consists of platinum of various thickness, and SiO₂ film of various thickness on LiTaO₃ substrate.

[0188]

At $\theta = 125$ degrees, it turns out that standardization thickness H/λ of the electrode with which thickness H_s/λ of SiO₂ consists of 0.1-0.40, and platinum has a small attenuation coefficient in the range of 0.005-0.06 so that clearly from drawing 76 . On the other hand, at $\theta = 140$ degrees, it turns out that the attenuation coefficient is [standardization thickness H/λ of the electrode which consists of platinum] large regardless of thickness H_s/λ of SiO₂ film in 0.005-0.06 so that clearly from drawing 77 .

[0189]

That is, in order to make the absolute value of TCF small, and to obtain a big electromechanical coupling coefficient and to make an attenuation coefficient small, it turns out that three conditions of the thickness of the electrode which consists of the thickness and platinum of the Eulerian angle of LiTaO₃ substrate and SiO₂ film must be taken into consideration.

[0190]

Drawing 78 - drawing 83 show the relation between θ (degree) of an Eulerian angle at the time of changing standardization thickness H/λ of the electrode layer which consists of standardization thickness H_s/λ and platinum of SiO₂ film, and an attenuation coefficient.

[0191]

It turns out that it is desirable for standardization thickness H/λ of the electrode which consists of platinum to make θ the range of 90 degrees - 169 degrees in 0.005-0.054 so that clearly from drawing 78 - drawing 83 . Moreover, if standardization thickness H/λ of the electrode which consists of platinum also takes into consideration that the relation between thickness H_s/λ of SiO₂ film and optimal θ reduces an attenuation coefficient α in 0.01-0.04, and 0.013-0.033, it will become as shown in the following Table 27 and 28. Here, as for the range of "the Eulerian angle of LiTaO₃" in Table 27 and 28, an attenuation coefficient specifies the range of 0.05 or less dB/ λ . Moreover, as for the range the Eulerian angle of LiTaO₃ in Table 27 and 28 "is more desirable in the range", an attenuation coefficient specifies the range of 0.025 or less dB/ λ . In addition, this -2 degrees - about +4 degrees optimal θ may vary by dispersion in the electrode digit of a platinum electrode, or dispersion of a single

crystal substrate.

[0192]

Moreover, although ± 3 degrees ϕ and ψ of an Eulerian angle varied from 0 degree at the time of manufacture, the property as a 0-degree thing that a property is almost the same was acquired.

[0193]

[Table 27]

白金 $H/\lambda = 0.01 \sim 0.04$ のとき

SiO ₂ 厚 (H_s/λ)	オイラー角	より好ましいオイラー角
$0.1 \leq H_s/\lambda < 0.15$	$(0 \pm 3^\circ, 90^\circ \sim 169^\circ, 0 \pm 3^\circ)$	$(0 \pm 3^\circ, 105^\circ \sim 153^\circ, 0 \pm 3^\circ)$
$0.15 \leq H_s/\lambda < 0.2$	$(0 \pm 3^\circ, 90^\circ \sim 167^\circ, 0 \pm 3^\circ)$	$(0 \pm 3^\circ, 105^\circ \sim 152^\circ, 0 \pm 3^\circ)$
$0.20 \leq H_s/\lambda < 0.25$	$(0 \pm 3^\circ, 90^\circ \sim 167^\circ, 0 \pm 3^\circ)$	$(0 \pm 3^\circ, 107^\circ \sim 152^\circ, 0 \pm 3^\circ)$
$0.25 \leq H_s/\lambda < 0.3$	$(0 \pm 3^\circ, 90^\circ \sim 164^\circ, 0 \pm 3^\circ)$	$(0 \pm 3^\circ, 104^\circ \sim 151^\circ, 0 \pm 3^\circ)$
$0.3 \leq H_s/\lambda < 0.4$	$(0 \pm 3^\circ, 90^\circ \sim 163^\circ, 0 \pm 3^\circ)$	$(0 \pm 3^\circ, 105^\circ \sim 150^\circ, 0 \pm 3^\circ)$

[0194]

[Table 28]

白金 $H/\lambda = 0.013 \sim 0.033$ のとき

SiO ₂ 厚 (H_s/λ)	オイラー角	より好ましいオイラー角
$0.1 \leq H_s/\lambda < 0.15$	$(0 \pm 3^\circ, 106^\circ \sim 155^\circ, 0 \pm 3^\circ)$	$(0 \pm 3^\circ, 116^\circ \sim 147.5^\circ, 0 \pm 3^\circ)$
$0.15 \leq H_s/\lambda < 0.2$	$(0 \pm 3^\circ, 104^\circ \sim 155^\circ, 0 \pm 3^\circ)$	$(0 \pm 3^\circ, 113.5^\circ \sim 150^\circ, 0 \pm 3^\circ)$
$0.20 \leq H_s/\lambda < 0.25$	$(0 \pm 3^\circ, 102^\circ \sim 155^\circ, 0 \pm 3^\circ)$	$(0 \pm 3^\circ, 111.5^\circ \sim 150^\circ, 0 \pm 3^\circ)$
$0.25 \leq H_s/\lambda < 0.3$	$(0 \pm 3^\circ, 102^\circ \sim 154^\circ, 0 \pm 3^\circ)$	$(0 \pm 3^\circ, 112^\circ \sim 146^\circ, 0 \pm 3^\circ)$
$0.3 \leq H_s/\lambda < 0.4$	$(0 \pm 3^\circ, 102^\circ \sim 153^\circ, 0 \pm 3^\circ)$	$(0 \pm 3^\circ, 110^\circ \sim 144.5^\circ, 0 \pm 3^\circ)$

[0195]

Namely, in order that thickness H/λ of the electrode which consists of platinum may improve the frequency temperature characteristic TCF in the case of 0.01-0.04 so that it may become within the limits of ± 20 ppm/degree C so that clearly from Table 27 and 28 When thickness H_s/λ of SiO₂ film is made into the range of 0.1-0.4, it turns out that θ in the Eulerian angle of LiTaO₃ should just choose the range of 0 degree - 79 degrees in the range of 90 degrees - 169 degrees, i.e., an angle of rotation.

[0196]

In order similarly for the standardization thickness of the electrode which consists of platinum film to be 0.01-0.04, and to improve the

frequency temperature characteristic TCF so that it may become within the limits of $\pm 20 \text{ ppm/degree C}$ so that clearly from Table 27 When thickness H_s/λ of SiO_2 film is made into the range of 0.1-0.4, it is good and, as for θ of the Eulerian angle of LiTaO_3 substrate, it turns out that what is necessary is the range of 90 degrees - 169 degrees, then just to choose the Eulerian angle of Table 27 according to the thickness of SiO_2 film more preferably.

[0197]

In order similarly for the standardization thickness of the electrode which consists of platinum film to be 0.013-0.033, and to improve the frequency temperature characteristic TCF so that it may become the range of $\pm 20 \text{ ppm/degree C}$ When thickness H_s/λ of SiO_2 film is made into the range of 0.1-0.4, it is good and, as for θ of the Eulerian angle of LiTaO_3 substrate, it turns out more preferably that what is necessary is the range of 102 degrees - 150 degrees, then just to choose the Eulerian angle of Table 28 according to thickness H_s/λ of SiO_2 film.

[0198]

Moreover, it converts and asks for the thickness of SiO_2 film in case the standardization thickness of the electrode layer which consists of platinum is 0.013-0.033, and the relation of an Eulerian angle from the standardization thickness of the electrode layer which consists of platinum shown in drawing 78 - drawing 83, and they are calculating thickness H_s/λ of SiO_2 film of Table 27 and 28, and the value of an Eulerian angle by it.

[0199]

After forming IDT which consists of a metal which uses platinum as a principal component on rotation Y cut X propagation LiTaO_3 substrate on the occasion of manufacture of the surface acoustic wave equipment concerning this invention, it is desirable to form SiO_2 film of thickness H_s/λ of the range which performs frequency regulation in the condition and can make an attenuation coefficient α small after an appropriate time. This is explained with reference to drawing 84 and drawing 85. Drawing 84 shows change of the acoustic velocity of the leakage surface acoustic wave at the time of forming SiO_2 film of IDT which consists of platinum of various thickness H/λ , and various thickness H_s/λ on the rotation Y cut X propagation LiTaO_3 substrate of an Eulerian angle (0 degree, 126 degrees, 0 degree). Moreover, drawing 85 shows change of the acoustic velocity of the leakage surface acoustic wave at the time of changing standardization thickness H_s/λ of SiO_2 film formed on it, when IDT which consists of platinum of various thickness H/λ is formed on the LiTaO_3 substrate of the

same Eulerian angle. If drawing 84 is compared with drawing 85, change of the acoustic velocity of a surface acoustic wave is far larger than the case where the direction at the time of changing the thickness of platinum changes the thickness of SiO₂ film so that clearly. Therefore, it is desirable to perform frequency regulation in advance of formation of SiO₂ film, for example, after forming IDT which consists of platinum by laser etching, ion etching, etc., it is desirable to perform frequency regulation.

[0200]

In addition, IDT which this invention becomes from 0 degree - 79 degree rotation Y cut X propagation, the piezo-electric substrate which consists of LiTaO₃ of (0 degree, 90 degrees - 169 degrees, 0 degree) by the Eulerian angle, and the platinum which is $H/\lambda = 0.005-0.054$ as mentioned above and $H_s/\lambda =$ it is not characterized by having SiO₂ film which is 0.10-0.40, and is not limited [therefore] especially about a number, structure, etc. of IDT. That is, this invention is applicable to various surface acoustic wave resonators, a surface acoustic wave filter, etc., as long as not only the surface acoustic wave equipment shown in drawing 1 but the above-mentioned conditions are fulfilled.

[0201]

[The example using nickel and molybdenum as an electrode material]

The surface acoustic wave equipment shown in drawing 15 was constituted. Nickel or molybdenum was used as an electrode material. Moreover, LiTaO₃ substrate of (0 degree, 104 degrees - 140 degrees, 0 degree) was used as a piezoelectric substrate by 14 degrees - 50 degree rotation Y cut X propagation and the Eulerian angle. Other points are the same.

[0202]

IDT(s) 23a and 23b and Reflectors 25a and 25b are constituted by the metal 1.8×10^{11} to 4×10^{11} Ns/m², and whose transverse-wave acoustic velocity 8700 - 10300 m/s and Young's modulus are 3170-3290 GPa for a consistency. As such a metal, the alloy which makes nickel, molybdenum, or these a subject is mentioned.

[0203]

Let standardization thickness H/λ (wavelength [in / H and / in λ / center frequency] is shown) of IDT(s) 23a and 23b be the range of 0.008-0.06. [the thickness of IDT]

The piezo-electric substrate 22 which consists of LiTaO₃ of (0 degree, 104 degrees - 140 degrees, 0 degree) as mentioned above in this example according to 14 degrees - 50 degree rotation Y cut X propagation and an Eulerian angle, IDT(s) 23a and 23b which are $H/\lambda = 0.008-0.06$ and

consist of the above-mentioned specific metal, and $H_s/\lambda =$ Since SiO₂ film 24 in the range of 0.10–0.40 is used, It is made small so that the frequency temperature coefficient TCF may become within the limits which is $\sim 20\text{ppm/degree C}$, and a propagation loss can offer small surface acoustic wave equipment greatly [an electromechanical coupling coefficient K_{sa}]. This is explained based on the following concrete examples of an experiment.

[0204]

drawing 86 and drawing 87 -- an Eulerian angle (0 degree, 120 degrees, 0 degree) and every of (0 degree, 140 degrees, 0 degree) -- it is drawing showing the attenuation coefficient at the time of forming IDT which consists of nickel of various thickness, and SiO₂ film of various thickness H_s/λ on LiTaO₃ substrate.

[0205]

At $\theta = 120$ degrees, it turns out that standardization thickness H/λ of the electrode with which thickness H_s/λ of SiO₂ consists of 0.1–0.40, and nickel has a small attenuation coefficient in the range of 0.008–0.08 so that clearly from drawing 86 . On the other hand, at $\theta = 140$ degrees, it turns out that the attenuation coefficient is [standardization thickness H/λ of the electrode which consists of nickel] large regardless of the thickness of SiO₂ film in 0.008–0.08 so that clearly from drawing 87 .

[0206]

drawing 88 and drawing 89 -- an Eulerian angle (0 degree, 120 degrees, 0 degree) and every of (0 degree, 140 degrees, 0 degree) -- it is drawing showing change of the attenuation coefficient at the time of forming IDT which consists of Mo of various thickness, and SiO₂ film of various thickness H_s/λ on LiTaO₃ substrate.

[0207]

At $\theta = 120$ degrees, it turns out that standardization thickness H/λ of the electrode with which thickness H_s/λ of SiO₂ consists of 0.1–0.40, and Mo has a small attenuation coefficient in the range of 0.008–0.08 so that clearly from drawing 88 . On the other hand, at $\theta = 140$ degrees, it turns out that the attenuation coefficient is [standardization thickness H/λ of the electrode which consists of Mo] large regardless of thickness H_s/λ of SiO₂ film in 0.008–0.08 so that clearly from drawing 89 .

[0208]

That is, in order to make the absolute value of TCF small, and to obtain a big electromechanical coupling coefficient and to make an attenuation coefficient small, it turns out that three conditions of the thickness

of the electrode which consists of a metal of thickness H_s/λ of the Eulerian angle of LiTaO_3 substrate and SiO_2 film and the above-mentioned specific consistency, Young's modulus, and the transverse-wave acoustic-velocity range must be taken into consideration.

[0209]

Drawing 90 - drawing 93 show the relation of the theta (degree) and the attenuation coefficient at the time of changing standardization thickness H/λ of the electrode layer which consists of standardization thickness H_s/λ and nickel of SiO_2 film.

Drawing 94 - drawing 97 show the relation of the theta (degree) and the attenuation coefficient at the time of changing standardization thickness H/λ of the electrode layer which consists of standardization thickness H_s/λ and Mo of SiO_2 film.

[0210]

In 0.008 to 0.06, 0.017-0.06, and 0.023-0.06, it becomes as standardization thickness H/λ of the electrode which consists of nickel or Mo shows the thickness of SiO_2 film, and the relation with optimal theta in the following table 29, so that clearly from drawing 90 - drawing 97. In addition, this -2 degrees - about +4 degrees optimal theta may vary by dispersion in the electrode digit of an electrode, or dispersion of a single crystal substrate.

[0211]

Moreover, although **3 degrees phi and psi of an Eulerian angle varied from 0 degree at the time of manufacture, the property as a 0-degree thing that a property is almost the same was acquired.

[0212]

[Table 29]

SiO_2	オイラー角	より好ましいオイラー角
0.1~0.2	$(0 \pm 3^\circ, 105^\circ \sim 140^\circ, 0 \pm 3^\circ)$	$(0 \pm 3^\circ, 110^\circ \sim 135^\circ, 0 \pm 3^\circ)$
0.2~0.3	$(0 \pm 3^\circ, 105^\circ \sim 140^\circ, 0 \pm 3^\circ)$	$(0 \pm 3^\circ, 108^\circ \sim 135^\circ, 0 \pm 3^\circ)$
0.3~0.4	$(0 \pm 3^\circ, 104^\circ \sim 139^\circ, 0 \pm 3^\circ)$	$(0 \pm 3^\circ, 108^\circ \sim 133^\circ, 0 \pm 3^\circ)$

[0213]

Moreover, optimal thickness H/λ of the electrode which consists of nickel shown by drawing 90 - drawing 93 = the relation between the thickness of SiO_2 film in 0.008 to 0.06, 0.02-0.06, and 0.027-0.06 and optimal theta becomes as it is shown in the following table 30.

[0214]

[Table 30]

SiO ₂	オイラー角	より好ましいオイラー角
0.1~0.2	(0±3°, 106° ~ 140°, 0±3°)	(0±3°, 110° ~ 135°, 0±3°)
0.2~0.3	(0±3°, 105° ~ 137°, 0±3°)	(0±3°, 108° ~ 134°, 0±3°)
0.3~0.4	(0±3°, 104° ~ 133°, 0±3°)	(0±3°, 108° ~ 132°, 0±3°)

[0215]

Moreover, optimal thickness H/λ of the electrode which consists of Mo shown in drawing 94 - drawing 97 = the thickness of SiO₂ film in 0.008 to 0.06, 0.017-0.06, and 0.023-0.06 and the relation with optimal theta become as they are shown in the following table 31.

[0216]

[Table 31]

SiO ₂	オイラー角	より好ましいオイラー角
0.1~0.2	(0±3°, 107° ~ 141°, 0±3°)	(0±3°, 110° ~ 135°, 0±3°)
0.2~0.3	(0±3°, 104° ~ 141°, 0±3°)	(0±3°, 109° ~ 135°, 0±3°)
0.3~0.4	(0±3°, 104° ~ 138°, 0±3°)	(0±3°, 108° ~ 133°, 0±3°)

[0217]

Thickness H/λ of the electrode which consists of a metal of the above-mentioned specific consistency, Young's modulus, and the transverse-wave acoustic-velocity range so that clearly from Table 29 namely, by 0.008 to 0.06, 0.017-0.06, and 0.023-0.06 In order to improve the frequency temperature characteristic TCF so that it may become within the limits of **20ppm/degree C, when thickness of SiO₂ film is made into the range of 0.1-0.4, theta in the Eulerian angle of LiTaO₃ It turns out in the range of 104 degrees - 140 degrees, i.e., an angle of rotation, that what is necessary is just to choose the range of 14 degrees - 50 degrees, and the Eulerian angle more preferably shown in Table 29.

[0218]

In order similarly to improve the frequency temperature characteristic TCF so that it may become within the limits of **20ppm/degree C when

standardization thickness H/λ of the electrode which consists of nickel film is 0.008 to 0.06, 0.02-0.06, and 0.027-0.06 It turns out that θ [in / according to thickness H_s/λ of SiO₂ film of 0.1-0.4 / in H_s/λ / the Eulerian angle of LiTaO₃ substrate] should just choose the range of 104 degrees - 140 degrees, then the Eulerian angle good and shown in Table 30 according to thickness H_s/λ of SiO₂ film more preferably.

[0219]

In order similarly to improve the frequency temperature characteristic TCF so that it may become within the limits of ± 20 ppm/degree C when standardization thickness H/λ of the electrode which consists of Mo film is 0.008 to 0.06, 0.02-0.06, and 0.027-0.06 It turns out that θ [in / according to thickness H_s/λ of SiO₂ film of 0.1-0.4 / in H_s/λ / the Eulerian angle of LiTaO₃ substrate] should just choose the range of 104 degrees - 141 degrees, then the Eulerian angle good and shown in Table 31 according to thickness H_s/λ of SiO₂ film more preferably.

[0220]

Here, as for the range of "the Eulerian angle of LiTaO₃" in Table 29 - 31, an attenuation coefficient α specifies the range of 0.1 or less dB/ λ . Moreover, as for the range the Eulerian angle of LiTaO₃ in Table 29 - 31 "is more desirable in the range", an attenuation coefficient specifies the range of 0.05 or less dB/ λ . Moreover, it converts and asks for thickness H_s/λ of SiO₂ film in case the standardization thickness of the above-mentioned electrode layer is 0.095, 0.017, and 0.023, and the relation of an Eulerian angle from the standardization thickness of the electrode layer which consists of nickel or Mo shown in drawing 90 - drawing 97 , and they are calculating the thickness of SiO₂ film of Table 29 - 31, and the value of an Eulerian angle by it.

[0221]

After forming IDT which consists of the above-mentioned specific metal of nickel, Mo, etc. on rotation Y cut X propagation LiTaO₃ substrate on the occasion of manufacture of the surface acoustic wave equipment concerning this invention, it is desirable to form SiO₂ film of the thickness of the range which performs frequency regulation in the condition and can make an attenuation coefficient α small after an appropriate time. This is explained with reference to drawing 98 - Fig. 101 . Drawing 98 and drawing 100 show change of the acoustic velocity of the leakage surface acoustic wave at the time of forming SiO₂ film of IDT which consists of nickel or Mo of various thickness H/λ , and

various thickness H_s/λ on the rotation Y cut X propagation LiTaO₃ substrate of an Eulerian angle (0 degree, 126 degrees, 0 degree). Moreover, drawing 99 and drawing 101 show change of the acoustic velocity of the leakage surface acoustic wave at the time of changing standardization thickness H_s/λ of SiO₂ film formed on it, when IDT which consists of nickel or Mo of various thickness H/λ is formed on the LiTaO₃ substrate of the same Eulerian angle. If drawing 98, drawing 99, and drawing 100 and drawing 101 are compared, change of the acoustic velocity of a surface acoustic wave is far larger than the case where the direction at the time of changing the thickness of an electrode changes the thickness of SiO₂ film so that clearly. Therefore, it is desirable to perform frequency regulation in advance of formation of SiO₂ film, for example, after forming IDT which consists of nickel or Mo by laser etching, ion etching, etc., it is desirable to perform frequency regulation.

[0222]

In addition, the piezo-electric substrate with which this invention consists of LiTaO₃ of (0 degree, 104 degrees - 140 degrees, 0 degree) as mentioned above by 14 degrees - 50 degree rotation Y cut X propagation and the Eulerian angle, H/λ = IDT which consists of a metal of the above-mentioned specific consistency of nickel, Mo, etc. which are 0.008-0.06, Young's modulus, and the transverse-wave acoustic-velocity range, H_s/λ = it is not characterized by having SiO₂ film which is 0.10-0.40, and is not limited [therefore] especially about a number, structure, etc. of IDT. That is, this invention is applicable to various surface acoustic wave resonators, a surface acoustic wave filter, etc., as long as not only the surface acoustic wave equipment shown in drawing 15 but the above-mentioned conditions are fulfilled.

[0223]

[Effect of the Invention]

In the remaining fields except the field in which the IDT electrode is formed with the surface acoustic wave equipment concerning the 1st invention In the configuration in which the 1st insulating material layer which was in an IDT electrode, abbreviation, etc. by carrying out, and was formed in thickness is prepared, and the 2nd insulating material layer is prepared so that an IDT electrode and the 1st insulating material layer may be covered Since an IDT electrode consists of an alloy which uses the metal or this metal of high density as a principal component rather than the consistency of the 1st insulating material layer, the reflection coefficient of an IDT electrode can be made into sufficient magnitude. Therefore, the good surface acoustic wave

equipment of the frequency temperature characteristic which degradation of the property by the ripple which is not a request cannot produce easily can be offered.

[0224]

In addition, since an IDT electrode and the 1st insulating material layer are in abbreviation etc. by carrying out, and it considers as thickness, and the laminating of the 2nd insulating material layer is carried out so that an IDT electrode and the 1st insulating material layer may be covered, flattening of the outside surface of the 2nd insulating material layer can be carried out, and it is hard to produce degradation of the property by the irregularity of the 2nd insulating material layer front face by it.

[0225]

With the surface acoustic wave equipment concerning the 2nd invention, the 1st insulating material layer of thickness almost equal to an IDT electrode is prepared in the remaining fields except the field in which the IDT electrode is formed, the protection metal membrane which consists of a metal or an alloy excellent in corrosion resistance is prepared on the IDT electrode rather than the metal or the alloy which constitutes an IDT electrode, and the 2nd insulating material layer is formed so that the protection metal membrane and 1st insulating material layer top may be covered. Therefore, since the IDT electrode is covered with the protection metal layer and the 1st insulating material layer, it is hard to produce the corrosion of an IDT electrode with the resist exfoliation liquid at the time of exfoliating a resist with a photolithography technique. Therefore, although it is easy to be corroded by resist exfoliation liquid, such as Cu, a consistency can constitute an IDT electrode using sufficiently big metal or alloy compared with aluminum, and can control degradation of the property of surface acoustic wave equipment effectively.

[0226]

In the 1st and 2nd invention, when the 1st and 2nd insulating material layer is constituted by SiO₂, according to this invention, the surface acoustic wave equipment with which the frequency temperature characteristic TCF has been improved can be offered.

[0227]

When an IDT electrode consists of an alloy which uses Cu or Cu as a principal component, compared with aluminum used widely as an electrode material of surface acoustic wave equipment from the former, the surface acoustic wave equipment which followed the 1st and 2nd invention since the consistency was large can be constituted easily, and the IDT

electrode of sufficient reflection coefficient can be formed easily.
[0228]

By the manufacture approach concerning the 3rd invention, after forming the 1st insulating material layer in the piezoelectric substrate 2 The insulating material layer of the part in which an IDT electrode is formed using a resist pattern is removed. The laminated structure of the 1st insulating material layer and a resist remains to the remaining fields. Next By forming the electrode layer which uses the metal or this metal of high density as a principal component rather than aluminum in the field to which the 1st insulating material layer is removed, an IDT electrode is formed and the resist which remains on the 1st insulating material layer is removed after an appropriate time. And since the 2nd insulating material layer is formed so that a 1st insulating material layer and IDT electrode top may be covered, it is hard to produce the irregularity on the top face of the 2nd insulating material layer. Therefore, it is hard to produce degradation of the property by the irregularity of the 2nd insulating material layer front face. In addition, since an IDT electrode consists of an alloy which uses the metal or this metal of high density as a principal component rather than aluminum, the reflection coefficient of an IDT electrode is raised and degradation of the property by the ripple which is not a request can be controlled.

[0229]

Moreover, according to the 4th invention, after forming an IDT electrode, the protection metal membrane which consists of a metal or an alloy excellent in corrosion resistance is formed, and the protection metal membrane by which the laminating is carried out on the resist on the 1st insulating material layer and this resist is removed from the metal or alloy which constitutes an IDT electrode after an appropriate time. Therefore, since it faces that resist exfoliation liquid performs this removal process, and the side face of an IDT electrode is covered with the 1st insulating material layer and the top face is covered with the protection metal layer, it is hard to produce the corrosion of an IDT electrode.

[0230]

Therefore, it becomes possible to offer the surface acoustic wave equipment concerning the 2nd invention, without causing the corrosion of an IDT electrode.

According to the 5th invention, after forming an electrode on a piezoelectric substrate, and forming an insulating material layer so that this electrode may be covered, flattening of the irregularity of the

front face of the insulating material layer above the part in which an electrode exists, and the part not existing is carried out. Therefore, it is hard to produce degradation of the property by the irregularity of an insulating material layer front face like the 1st invention.

[Brief Description of the Drawings]

[Drawing 1] (a) - (g) is each typical partial notching sectional view for explaining the manufacture approach of the surface acoustic wave equipment in one example of this invention.

[Drawing 2] Drawing showing the relation between the electrode layer thickness when having not carried out flattening to the case where flattening of the front face of SiO₂ film is carried out, in 1 port mold surface acoustic wave resonator to which the IDT electrode which consists of aluminum, Au, or Pt by various thickness is formed on the LiTaO₃ substrate of an Eulerian angle (0 degree, 126 degrees, 0 degree), and standardization thickness H_s/λ comes to form SiO₂ film of 0.2 further, and a reflection coefficient.

[Drawing 3] Drawing showing the relation between the electrode layer thickness when having not carried out flattening to the case where flattening of the front face of SiO₂ film is carried out, in 1 port mold surface acoustic wave resonator to which the IDT electrode which consists of aluminum, Cu, or Ag by various thickness is formed on the LiTaO₃ substrate of an Eulerian angle (0 degree, 126 degrees, 0 degree), and standardization thickness H_s/λ comes to form SiO₂ film of 0.2 further, and a reflection coefficient.

[Drawing 4] Drawing showing the relation between the standardization thickness of SiO₂ film of the surface acoustic wave resonator obtained by the manufacture approach of the example of a comparison, and a phase characteristic and an impedance characteristic.

[Drawing 5] Drawing showing the relation between the thickness of SiO₂ film in the surface acoustic wave resonator prepared for the comparison, and MF of a resonator.

[Drawing 6] The typical top view of 1 port mold surface acoustic wave resonator obtained in the one example of this invention.

[Drawing 7] Drawing showing change of the impedance characteristic at the time of changing the standardization thickness of SiO₂ film, and a phase characteristic in the manufacture approach of an example.

[Drawing 8] Drawing showing the relation of the thickness of SiO₂ film and gamma of a resonator in the surface acoustic wave resonator obtained by the manufacture approach of an example and the example of a comparison.

[Drawing 9] Drawing showing the relation of the thickness of SiO₂ film

and MF of a resonator in the surface acoustic wave resonator obtained by the manufacture approach of an example and the example of a comparison.

[Drawing 10] Drawing showing the relation between the thickness of SiO₂ film in the surface acoustic wave resonator prepared in the example and the example of a comparison, and change of the frequency temperature characteristic TCF.

[Drawing 11] Drawing showing the impedance-frequency characteristics which do not have SiO₂ film with the surface acoustic wave resonator in which SiO₂ film prepared in the 2nd example of a comparison was formed.

[Drawing 12] (a) - (e) is drawing showing change of the impedance characteristic at the time of changing the ratio to the consistency of the 1st insulating material layer of the mean density of an IDT electrode and a protection metal membrane.

[Drawing 13] Drawing showing change of the electromechanical coupling coefficient at the time of forming the IDT electrode which consists of various metals by various thickness on the LiTaO₃ substrate of an Eulerian angle (0 degree, 126 degrees, 0 degree).

[Drawing 14] Drawing showing relation with the consistency of the electrode layer Atsunori enclosure and electrode material with which an electromechanical coupling coefficient becomes large compared with the case where the electrode which consists of aluminum is used when an IDT electrode is formed with various metals on LiTaO₃ substrate.

[Drawing 15] The perspective view showing the surface acoustic wave equipment concerning other examples of this invention.

[Drawing 16] Drawing showing the relation of the electrode layer thickness and the electromechanical coupling coefficient by which IDT at the time of forming IDT which consists of IDT and aluminum which consist of Au, Ta, Ag, Cr, W, Cu, Zn, Mo, and nickel on the LiTaO₃ substrate of 36-degree rotation Y cut X propagation (they are (0 degree, 126 degrees, 0 degree) at an Eulerian angle) was standardized.

[Drawing 17] 36-degree rotation Y cut X propagation (drawing showing the reflection coefficient of electrode finger one of the two of IDT and the relation of thickness it is unrelated from various electrode materials on the LiTaO₃ substrate of (0 degree, 126 degrees, 0 degree) by the Eulerian angle.)

[Drawing 18] Drawing showing the relation between the electrode standardization thickness of IDT at the time of forming IDT which consists of IDT and aluminum which consist of Au, Ta, Ag, Cr, W, Cu, Zn, Mo, and nickel on the LiTaO₃ substrate of 36-degree rotation Y cut X propagation (they are (0 degree, 126 degrees, 0 degree) at an Eulerian angle), and an attenuation coefficient.

[Drawing 19] Drawing showing change of the frequency temperature characteristic (TCF) when standardization thickness forms IDT which consists of Au which is 0.02 and forms SiO₂ film of various thickness on the LiTaO₃ substrate of 36-degree rotation Y cut X propagation (they are (0 degree, 126 degrees, 0 degree) at an Eulerian angle).

[Drawing 20] Drawing showing change of the attenuation coefficient α at the time of changing the SiO₂ film standardization thickness which forms IDT which consists of Au of various thickness on the LiTaO₃ substrate of 36-degree rotation Y cut X propagation (they are (0 degree, 126 degrees, 0 degree) at an Eulerian angle), and turns a laminating up further.

[Drawing 21] Drawing showing change of the attenuation coefficient α at the time of changing the SiO₂ film standardization thickness which forms IDT which consists of Au of various thickness on the LiTaO₃ substrate of 38-degree rotation Y cut X propagation (they are (0 degree, 128 degrees, 0 degree) at an Eulerian angle), and turns a laminating up further.

[Drawing 22] Drawing showing the magnitude-of-attenuation frequency characteristics of the surface acoustic wave equipment for the comparison before the magnitude-of-attenuation frequency characteristics of the surface acoustic wave equipment of an example, and SiO₂ film membrane formation.

[Drawing 23] Drawing showing change of the acoustic velocity of the leakage surface acoustic wave at the time of changing the standardization thickness of IDT which consists of Au in the structure which formed IDT which consists of Au and formed SiO₂ film of various thickness on the LiTaO₃ substrate of 36-degree rotation Y cut X propagation (they are (0 degree, 126 degrees, 0 degree) at an Eulerian angle).

[Drawing 24] Drawing showing change of the acoustic velocity of the leakage surface acoustic wave at the time of changing the standardization thickness of SiO₂ film in the structure which formed IDT which consists of Au of various standardization thickness on the LiTaO₃ substrate of 36-degree rotation Y cut X propagation (they are (0 degree, 126 degrees, 0 degree) at an Eulerian angle), and was further made into the SiO₂ film laminating.

[Drawing 25] Drawing showing change of the electromechanical coupling coefficient at the time of changing the standardization thickness of IDT which consists of theta of (0 degree, theta, 0 degree), and Au by the Eulerian angle, and the standardization thickness of SiO₂ film.

[Drawing 26] Drawing showing change of the Q value of the resonator at

the time of changing theta of the Eulerian angle of LiTaO₃ substrate, and the standardization thickness of SiO₂ film.

[Drawing 27] (a) - (c) is each typical sectional view for explaining the surface acoustic wave equipment concerning the modification of this invention in which the adhesion layer was prepared.

[Drawing 28] Thickness H/λ of SiO₂ film = drawing showing the relation of the attenuation coefficients alpha and theta in various Au electrode layer thickness in 0.1.

[Drawing 29] Thickness H/λ of SiO₂ film = drawing showing the relation of the attenuation coefficients alpha and theta in various Au electrode layer thickness in 0.15.

[Drawing 30] Thickness H/λ of SiO₂ film = drawing showing the relation of the attenuation coefficients alpha and theta in various Au electrode layer thickness in 0.2.

[Drawing 31] Thickness H/λ of SiO₂ film = drawing showing the relation of the attenuation coefficients alpha and theta in various Au electrode layer thickness in 0.25.

[Drawing 32] Thickness H/λ of SiO₂ film = drawing showing the relation of the attenuation coefficients alpha and theta in various Au electrode layer thickness in 0.3.

[Drawing 33] Thickness H/λ of SiO₂ film = drawing showing the relation of the attenuation coefficients alpha and theta in various Au electrode layer thickness in 0.35.

[Drawing 34] Thickness H/λ of SiO₂ film = drawing showing the relation of the attenuation coefficients alpha and theta in various Au electrode layer thickness in 0.4.

[Drawing 35] Thickness H/λ of SiO₂ film = drawing showing the relation of the attenuation coefficients alpha and theta in various Au electrode layer thickness in 0.45.

[Drawing 36] Drawing showing relation with an electromechanical coupling coefficient K_{SAW} with standardization thickness H/λ of Ag film at the time of forming the electrode which consists of Ag film of various thickness on the LiTaO₃ substrate of an Eulerian angle (0 degree, 126 degrees, 0 degree).

[Drawing 37] an Eulerian angle (0 degree, 113 degrees, 0 degree) -- and (0 degree, 126 degrees, 0 degree) (0 degree, 129 degrees, 0 degree) drawing showing the relation between standardization thickness H_s/λ of SiO₂ film when electrode layer thickness forms SiO₂ film of various thickness by 0, and the frequency temperature coefficient TCF in three kinds of LiTaO₃ substrates.

[Drawing 38] Drawing showing change of the attenuation coefficient alpha

at the time of forming Ag film of 0.1 or less standardization thickness on the LiTaO₃ substrate of an Eulerian angle (0 degree, 120 degrees, 0 degree), and forming SiO₂ film of the standardization thickness of 0-0.5.

[Drawing 39] Drawing showing change of the attenuation coefficient α at the time of forming Ag film of 0.1 or less standardization thickness on the LiTaO₃ substrate of an Eulerian angle (0 degree, 140 degrees, 0 degree), and forming SiO₂ film of the standardization thickness of 0-0.5.

[Drawing 40] Drawing showing change of an attenuation coefficient α when standardization thickness H/λ forms 0.1 or less various Ag film on the LiTaO₃ substrate of an Eulerian angle (0 degree, θ , 0 degree) and standardization thickness H_s/λ carries out the laminating of the SiO₂ film of 0.1.

[Drawing 41] Drawing showing change of an attenuation coefficient α when standardization thickness H/λ forms 0.1 or less various Ag film on the LiTaO₃ substrate of an Eulerian angle (0 degree, θ , 0 degree) and standardization thickness H_s/λ carries out the laminating of the SiO₂ film of 0.15.

[Drawing 42] Drawing showing change of an attenuation coefficient α when standardization thickness H/λ forms 0.1 or less various Ag film on the LiTaO₃ substrate of an Eulerian angle (0 degree, θ , 0 degree) and standardization thickness H_s/λ carries out the laminating of the SiO₂ film of 0.2.

[Drawing 43] Drawing showing change of an attenuation coefficient α when standardization thickness H/λ forms 0.1 or less various Ag film on the LiTaO₃ substrate of an Eulerian angle (0 degree, θ , 0 degree) and standardization thickness H_s/λ carries out the laminating of the SiO₂ film of 0.25.

[Drawing 44] Drawing showing change of an attenuation coefficient α when standardization thickness H/λ forms 0.1 or less various Ag film on the LiTaO₃ substrate of an Eulerian angle (0 degree, θ , 0 degree) and standardization thickness H_s/λ carries out the laminating of the SiO₂ film of 0.3.

[Drawing 45] Drawing showing change of an attenuation coefficient α when standardization thickness H/λ forms 0.1 or less various Ag film on the LiTaO₃ substrate of an Eulerian angle (0 degree, θ , 0 degree) and standardization thickness H_s/λ carries out the laminating of the SiO₂ film of 0.35.

[Drawing 46] Drawing showing change of an attenuation coefficient α when standardization thickness H/λ forms 0.1 or less various Ag film on the LiTaO₃ substrate of an Eulerian angle (0 degree, θ , 0 degree) and standardization thickness H_s/λ carries out the

laminating of the SiO₂ film of 0.4.

[Drawing 47] Drawing showing change of an attenuation coefficient α when standardization thickness H/λ forms 0.1 or less various Ag film on the LiTaO₃ substrate of an Eulerian angle (0 degree, θ , 0 degree) and standardization thickness H_s/λ carries out the laminating of the SiO₂ film of 0.45.

[Drawing 48] Drawing showing change of the attenuation coefficient α at the time of forming Cu film of 0.1 or less standardization thickness on the LiTaO₃ substrate of an Eulerian angle (0 degree, 120 degrees, 0 degree), and forming SiO₂ film of the standardization thickness of 0-0.5.

[Drawing 49] Drawing showing change of the attenuation coefficient α at the time of forming Cu film of 0.1 or less standardization thickness on the LiTaO₃ substrate of an Eulerian angle (0 degree, 135 degrees, 0 degree), and forming SiO₂ film of the standardization thickness of 0-0.5.

[Drawing 50] Drawing showing change of an attenuation coefficient α when standardization thickness H/λ forms 0.1 or less various Cu film on the LiTaO₃ substrate of an Eulerian angle (0 degree, θ , 0 degree) and standardization thickness H_s/λ carries out the laminating of the SiO₂ film of 0.1.

[Drawing 51] Drawing showing change of an attenuation coefficient α when standardization thickness H/λ forms 0.1 or less various Cu film on the LiTaO₃ substrate of an Eulerian angle (0 degree, θ , 0 degree) and standardization thickness H_s/λ carries out the laminating of the SiO₂ film of 0.15.

[Drawing 52] Drawing showing change of an attenuation coefficient α when standardization thickness H/λ forms 0.1 or less various Cu film on the LiTaO₃ substrate of an Eulerian angle (0 degree, θ , 0 degree) and standardization thickness H_s/λ carries out the laminating of the SiO₂ film of 0.2.

[Drawing 53] Drawing showing change of an attenuation coefficient α when standardization thickness H/λ forms 0.1 or less various Cu film on the LiTaO₃ substrate of an Eulerian angle (0 degree, θ , 0 degree) and standardization thickness H_s/λ carries out the laminating of the SiO₂ film of 0.25.

[Drawing 54] Drawing showing change of an attenuation coefficient α when standardization thickness H/λ forms 0.1 or less various Cu film on the LiTaO₃ substrate of an Eulerian angle (0 degree, θ , 0 degree) and standardization thickness H_s/λ carries out the laminating of the SiO₂ film of 0.3.

[Drawing 55] Drawing showing change of an attenuation coefficient α when standardization thickness H/λ forms 0.1 or less various Cu

film on the LiTaO₃ substrate of an Eulerian angle (0 degree, θ , 0 degree) and standardization thickness H_s/λ carries out the laminating of the SiO₂ film of 0.35.

[Drawing 56] Drawing showing change of an attenuation coefficient α when standardization thickness H/λ forms 0.1 or less various Cu film on the LiTaO₃ substrate of an Eulerian angle (0 degree, θ , 0 degree) and standardization thickness H_s/λ carries out the laminating of the SiO₂ film of 0.4.

[Drawing 57] Drawing showing change of an attenuation coefficient α when standardization thickness H/λ forms 0.1 or less various Cu film on the LiTaO₃ substrate of an Eulerian angle (0 degree, θ , 0 degree) and standardization thickness H_s/λ carries out the laminating of the SiO₂ film of 0.45.

[Drawing 58] Drawing showing the relation of the reflection factor per electrode finger and electrode layer thickness in the electrode which consists of an electrode which consists of aluminum in case the standardization thickness of SiO₂ film is 0.02, and Cu.

[Drawing 59] Drawing showing the relation between standardization thickness H_s/λ of SiO₂ film for realizing θ_{\min} from which an attenuation coefficient serves as 0 or min, and standardization thickness H/λ of Cu film.

[Drawing 60] Drawing showing change of the attenuation coefficient α in the structure in which IDT which consists of SiO₂ film of various thickness and a tungsten of various thickness was formed on the LiTaO₃ substrate of an Eulerian angle (0 degree, 120 degrees, 0 degree).

[Drawing 61] Drawing showing change of the attenuation coefficient α in the structure in which IDT which consists of SiO₂ film of various thickness and a tungsten of various thickness was formed on the LiTaO₃ substrate of an Eulerian angle (0 degree, 140 degrees, 0 degree).

[Drawing 62] Drawing showing relation with an attenuation coefficient α with θ in the surface acoustic wave equipment which formed the electrode layer which consists of a tungsten of various thickness, and formed SiO₂ film of standardization thickness $H_s/\lambda = 0.1$ further on the LiTaO₃ substrate of an Eulerian angle (0 degree, θ , 0 degree), and standardization thickness H/λ of the electrode layer which consists of a tungsten.

[Drawing 63] Drawing showing relation with an attenuation coefficient α with θ in the surface acoustic wave equipment which formed the electrode layer which consists of a tungsten of various thickness, and formed SiO₂ film of standardization thickness $H_s/\lambda = 0.2$ further on the LiTaO₃ substrate of an Eulerian angle (0 degree, θ , 0 degree),

and standardization thickness H/λ of the electrode layer which consists of a tungsten.

[Drawing 64] Drawing showing relation with an attenuation coefficient α with θ in the surface acoustic wave equipment which formed the electrode layer which consists of a tungsten of various thickness, and formed SiO₂ film of standardization thickness $H_s/\lambda = 0.3$ further on the LiTaO₃ substrate of an Eulerian angle (0 degree, θ , 0 degree), and standardization thickness H/λ of the electrode layer which consists of a tungsten.

[Drawing 65] Drawing showing relation with an attenuation coefficient α with θ in the surface acoustic wave equipment which formed the electrode layer which consists of a tungsten of various thickness, and formed SiO₂ film of standardization thickness $H_s/\lambda = 0.4$ further on the LiTaO₃ substrate of an Eulerian angle (0 degree, θ , 0 degree), and standardization thickness H/λ of the electrode layer which consists of a tungsten.

[Drawing 66] Drawing showing the thickness of the tungsten film at the time of forming IDT which consists of a tungsten and forming SiO₂ film further on the LiTaO₃ substrate of an Eulerian angle (0 degree, 126 degrees, 0 degree), the thickness of SiO₂ film, and relation with acoustic velocity.

[Drawing 67] Drawing showing the thickness of the tungsten film at the time of forming IDT which consists of a tungsten and forming SiO₂ film further on the LiTaO₃ substrate of an Eulerian angle (0 degree, 126 degrees, 0 degree), the thickness of SiO₂ film, and relation with acoustic velocity.

[Drawing 68] Drawing showing change of the attenuation coefficient α in the structure in which IDT which consists of a tantalum of SiO₂ film of various thickness and various thickness was formed on the LiTaO₃ substrate of an Eulerian angle (0 degree, 120 degrees, 0 degree).

[Drawing 69] Drawing showing change of the attenuation coefficient α in the structure in which IDT which consists of a tantalum of SiO₂ film of various thickness and various thickness was formed on the LiTaO₃ substrate of an Eulerian angle (0 degree, 140 degrees, 0 degree).

[Drawing 70] Drawing showing relation with an attenuation coefficient α with θ in the surface acoustic wave equipment which formed the electrode layer which consists of a tantalum of various thickness, and formed SiO₂ film of standardization thickness $H_s/\lambda = 0.1$ further on the LiTaO₃ substrate of an Eulerian angle (0 degree, θ , 0 degree), and standardization thickness H/λ of the electrode layer which consists of a tantalum.

[Drawing 71] Drawing showing relation with an attenuation coefficient α with θ in the surface acoustic wave equipment which formed the electrode layer which consists of a tantalum of various thickness, and formed SiO₂ film of standardization thickness $H_s/\lambda = 0.2$ further on the LiTaO₃ substrate of an Eulerian angle (0 degree, θ , 0 degree), and standardization thickness H/λ of the electrode layer which consists of a tantalum.

[Drawing 72] Drawing showing relation with an attenuation coefficient α with θ in the surface acoustic wave equipment which formed the electrode layer which consists of a tantalum of various thickness, and formed SiO₂ film of standardization thickness $H_s/\lambda = 0.3$ further on the LiTaO₃ substrate of an Eulerian angle (0 degree, θ , 0 degree), and standardization thickness H/λ of the electrode layer which consists of a tantalum.

[Drawing 73] Drawing showing relation with an attenuation coefficient α with θ in the surface acoustic wave equipment which formed the electrode layer which consists of a tantalum of various thickness, and formed SiO₂ film of standardization thickness $H_s/\lambda = 0.4$ further on the LiTaO₃ substrate of an Eulerian angle (0 degree, θ , 0 degree), and standardization thickness H/λ of the electrode layer which consists of a tantalum.

[Drawing 74] Drawing showing relation with acoustic velocity with the standardization thickness of a tantalum in the structure which formed IDT which consists of a tantalum on the LiTaO₃ substrate of an Eulerian angle (0 degree, 126 degrees, 0 degree), and formed SiO₂ film on it, and the standardization thickness of SiO₂.

[Drawing 75] Drawing showing relation with acoustic velocity with the standardization thickness of a tantalum in the structure where IDT which consists of a tantalum is formed on the LiTaO₃ substrate of an Eulerian angle (0 degree, 126 degrees, 0 degree), and SiO₂ film was formed on it, and the standardization thickness of SiO₂.

[Drawing 76] Drawing showing change of the attenuation coefficient α in the structure in which IDT which consists of SiO₂ film of various thickness and platinum of various thickness was formed on the LiTaO₃ substrate of an Eulerian angle (0 degree, 125 degrees, 0 degree).

[Drawing 77] Drawing showing change of the attenuation coefficient α in the structure in which IDT which consists of SiO₂ film of various thickness and platinum of various thickness was formed on the LiTaO₃ substrate of an Eulerian angle (0 degree, 140 degrees, 0 degree).

[Drawing 78] Drawing showing relation with an attenuation coefficient α with θ in the surface acoustic wave equipment which formed the

electrode layer which consists of platinum of various thickness, and formed SiO₂ film of standardization thickness $H_s/\lambda = 0.1$ further on the LiTaO₃ substrate of an Eulerian angle (0 degree, θ , 0 degree), and standardization thickness H/λ of the electrode layer which consists of platinum.

[Drawing 79] Drawing showing relation with an attenuation coefficient α with θ in the surface acoustic wave equipment which formed the electrode layer which consists of platinum of various thickness, and formed SiO₂ film of standardization thickness $H_s/\lambda = 0.15$ further on the LiTaO₃ substrate of an Eulerian angle (0 degree, θ , 0 degree), and standardization thickness H/λ of the electrode layer which consists of platinum.

[Drawing 80] Drawing showing relation with an attenuation coefficient α with θ in the surface acoustic wave equipment which formed the electrode layer which consists of platinum of various thickness, and formed SiO₂ film of standardization thickness $H_s/\lambda = 0.2$ further on the LiTaO₃ substrate of an Eulerian angle (0 degree, θ , 0 degree), and standardization thickness H/λ of the electrode layer which consists of platinum.

[Drawing 81] Drawing showing relation with an attenuation coefficient α with θ in the surface acoustic wave equipment which formed the electrode layer which consists of platinum of various thickness, and formed SiO₂ film of standardization thickness $H_s/\lambda = 0.25$ further on the LiTaO₃ substrate of an Eulerian angle (0 degree, θ , 0 degree), and standardization thickness H/λ of the electrode layer which consists of platinum.

[Drawing 82] Drawing showing relation with an attenuation coefficient α with θ in the surface acoustic wave equipment which formed the electrode layer which consists of platinum of various thickness, and formed SiO₂ film of standardization thickness $H_s/\lambda = 0.3$ further on the LiTaO₃ substrate of an Eulerian angle (0 degree, θ , 0 degree), and standardization thickness H/λ of the electrode layer which consists of platinum.

[Drawing 83] Drawing showing relation with an attenuation coefficient α with θ in the surface acoustic wave equipment which formed the electrode layer which consists of platinum of various thickness, and formed SiO₂ film of standardization thickness $H_s/\lambda = 0.4$ further on the LiTaO₃ substrate of an Eulerian angle (0 degree, θ , 0 degree), and standardization thickness H/λ of the electrode layer which consists of platinum.

[Drawing 84] Drawing showing the thickness of the platinum film at the

time of forming IDT which consists of platinum and forming SiO₂ film further on the LiTaO₃ substrate of an Eulerian angle (0 degree, 126 degrees, 0 degree), the thickness of SiO₂ film, and relation with acoustic velocity.

[Drawing 85] Drawing showing the thickness of the platinum film at the time of forming IDT which consists of platinum and forming SiO₂ film further on the LiTaO₃ substrate of an Eulerian angle (0 degree, 126 degrees, 0 degree), the thickness of SiO₂ film, and relation with acoustic velocity.

[Drawing 86] Drawing showing change of the attenuation coefficient α in the structure in which IDT which consists of SiO₂ film of various thickness and nickel of various thickness was formed on the LiTaO₃ substrate of an Eulerian angle (0 degree, 120 degrees, 0 degree).

[Drawing 87] Drawing showing change of the attenuation coefficient α in the structure in which IDT which consists of SiO₂ film of various thickness and nickel of various thickness was formed on the LiTaO₃ substrate of an Eulerian angle (0 degree, 140 degrees, 0 degree).

[Drawing 88] Drawing showing change of the attenuation coefficient α in the structure in which IDT which consists of SiO₂ film of various thickness and molybdenum of various thickness was formed on the LiTaO₃ substrate of an Eulerian angle (0 degree, 120 degrees, 0 degree).

[Drawing 89] Drawing showing change of the attenuation coefficient α in the structure in which IDT which consists of SiO₂ film of various thickness and molybdenum of various thickness was formed on the LiTaO₃ substrate of an Eulerian angle (0 degree, 140 degrees, 0 degree).

[Drawing 90] Drawing showing relation with an attenuation coefficient α with θ in the surface acoustic wave equipment which formed the electrode layer which consists of nickel of various thickness, and formed SiO₂ film of standardization thickness $H_s/\lambda = 0.1$ further on the LiTaO₃ substrate of an Eulerian angle (0 degree, θ , 0 degree), and standardization thickness H/λ of the electrode layer which consists of nickel.

[Drawing 91] Drawing showing relation with an attenuation coefficient α with θ in the surface acoustic wave equipment which formed the electrode layer which consists of nickel of various thickness, and formed SiO₂ film of standardization thickness $H_s/\lambda = 0.2$ further on the LiTaO₃ substrate of an Eulerian angle (0 degree, θ , 0 degree), and standardization thickness H/λ of the electrode layer which consists of nickel.

[Drawing 92] Drawing showing relation with an attenuation coefficient α with θ in the surface acoustic wave equipment which formed the

electrode layer which consists of nickel of various thickness, and formed SiO₂ film of standardization thickness $H_s/\lambda = 0.3$ further on the LiTaO₃ substrate of an Eulerian angle (0 degree, θ , 0 degree), and standardization thickness H/λ of the electrode layer which consists of nickel.

[Drawing 93] Drawing showing relation with an attenuation coefficient α with θ in the surface acoustic wave equipment which formed the electrode layer which consists of nickel of various thickness, and formed SiO₂ film of standardization thickness $H_s/\lambda = 0.4$ further on the LiTaO₃ substrate of an Eulerian angle (0 degree, θ , 0 degree), and standardization thickness H/λ of the electrode layer which consists of nickel.

[Drawing 94] Drawing showing relation with an attenuation coefficient α with θ in the surface acoustic wave equipment which formed the electrode layer which consists of molybdenum of various thickness, and formed SiO₂ film of standardization thickness $H_s/\lambda = 0.1$ further on the LiTaO₃ substrate of an Eulerian angle (0 degree, θ , 0 degree), and standardization thickness H/λ of the electrode layer which consists of molybdenum.

[Drawing 95] Drawing showing relation with an attenuation coefficient α with θ in the surface acoustic wave equipment which formed the electrode layer which consists of molybdenum of various thickness, and formed SiO₂ film of standardization thickness $H_s/\lambda = 0.2$ further on the LiTaO₃ substrate of an Eulerian angle (0 degree, θ , 0 degree), and standardization thickness H/λ of the electrode layer which consists of molybdenum.

[Drawing 96] Drawing showing relation with an attenuation coefficient α with θ in the surface acoustic wave equipment which formed the electrode layer which consists of molybdenum of various thickness, and formed SiO₂ film of standardization thickness $H_s/\lambda = 0.3$ further on the LiTaO₃ substrate of an Eulerian angle (0 degree, θ , 0 degree), and standardization thickness H/λ of the electrode layer which consists of molybdenum.

[Drawing 97] Drawing showing relation with an attenuation coefficient α with θ in the surface acoustic wave equipment which formed the electrode layer which consists of molybdenum of various thickness, and formed SiO₂ film of standardization thickness $H_s/\lambda = 0.4$ further on the LiTaO₃ substrate of an Eulerian angle (0 degree, θ , 0 degree), and standardization thickness H/λ of the electrode layer which consists of molybdenum.

[Drawing 98] Drawing showing the thickness of the nickel film when IDT

which consists of nickel is formed on the LiTaO₃ substrate of an Eulerian angle (0 degree, 126 degrees, 0 degree) and SiO₂ film of still more various thickness is formed, the thickness of the nickel film, and relation with acoustic velocity.

[Drawing 99] Drawing in which forming IDT which consists of nickel of various thickness on the LiTaO₃ substrate of an Eulerian angle (0 degree, 126 degrees, 0 degree), forming SiO₂ film on it, and showing the thickness of SiO₂ film in structure, and relation with acoustic velocity.

[Drawing 100] Drawing showing relation with acoustic velocity with the standardization thickness of the molybdenum in structure when IDT which becomes since it consists of molybdenum is formed on the LiTaO₃ substrate of an Eulerian angle (0 degree, 126 degrees, 0 degree) and SiO₂ film of various thickness is formed on it.

[Drawing 101] Drawing showing relation with acoustic velocity with the standardization thickness of SiO₂ film in the structure which formed IDT which consists of molybdenum of various thickness, and formed SiO₂ film further on the LiTaO₃ substrate of an Eulerian angle (0 degree, 126 degrees, 0 degree).

[Drawing 102] (a) - (c) is each typical sectional view for explaining the etchback method as an example of an approach which attains flattening of an insulating material layer front face.

[Drawing 103] (a) - (d) is each typical sectional view for explaining the reverse spatter as other examples of the approach of carrying out flattening of the insulating material layer front face.

[Drawing 104] (a) And (b) is the typical sectional view showing the example of further others of the approach of carrying out flattening of the insulating material layer front face.

[Drawing 105] (a) - (c) is each typical sectional view for explaining an option to the pan which carries out flattening of the insulating material layer front face.

[Drawing 106] (a) And (b) is each typical top view for explaining 1 port mold resonator as an example of surface acoustic wave equipment and 2 port mold resonator to which this invention is applied.

[Drawing 107] The typical top view for explaining the ladder mold filter as surface acoustic wave equipment with which this invention is applied.

[Drawing 108] The typical top view for explaining the lattice mold filter as surface acoustic wave equipment with which this invention is applied.

[Drawing 109] (a) - (d) is a typical sectional view to show an example of the manufacture approach of conventional surface acoustic wave equipment.

[Drawing 110] The typical transverse-plane sectional view for explaining an example of conventional surface acoustic wave equipment. .

[Description of Notations]

1 -- LiTaO₃ substrate
2 -- The 1st insulating material layer
3 -- Resist pattern
4 -- Metal membrane
Four A--IDT electrodes
5 -- Ti film as a protection metal membrane
6 -- The 2nd insulating material layer
11 -- Surface acoustic wave resonator
12 13 -- Reflector
21 -- Surface acoustic wave equipment
22 -- LiTaO₃ substrate
23a, 23 b--IDT
25 -- SiO₂ film

[Translation done.]

* NOTICES *

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1. This document has been translated by computer. So the translation may not reflect the original precisely.
2. **** shows the word which can not be translated.
3. In the drawings, any words are not translated.

DESCRIPTION OF DRAWINGS

[Brief Description of the Drawings]

[Drawing 1] (a) - (g) is each typical partial notching sectional view for explaining the manufacture approach of the surface acoustic wave equipment in one example of this invention.

[Drawing 2] Drawing showing the relation between the electrode layer thickness when having not carried out flattening to the case where flattening of the front face of SiO₂ film is carried out, in 1 port mold surface acoustic wave resonator to which the IDT electrode which consists of aluminum, Au, or Pt by various thickness is formed on the LiTaO₃ substrate of an Eulerian angle (0 degree, 126 degrees, 0 degree),

and standardization thickness H_s/λ comes to form SiO₂ film of 0.2 further, and a reflection coefficient.

[Drawing 3] Drawing showing the relation between the electrode layer thickness when having not carried out flattening to the case where flattening of the front face of SiO₂ film is carried out, in 1 port mold surface acoustic wave resonator to which the IDT electrode which consists of aluminum, Cu, or Ag by various thickness is formed on the LiTaO₃ substrate of an Eulerian angle (0 degree, 126 degrees, 0 degree), and standardization thickness H_s/λ comes to form SiO₂ film of 0.2 further, and a reflection coefficient.

[Drawing 4] Drawing showing the relation between the standardization thickness of SiO₂ film of the surface acoustic wave resonator obtained by the manufacture approach of the example of a comparison, and a phase characteristic and an impedance characteristic.

[Drawing 5] Drawing showing the relation between the thickness of SiO₂ film in the surface acoustic wave resonator prepared for the comparison, and MF of a resonator.

[Drawing 6] The typical top view of 1 port mold surface acoustic wave resonator obtained in the one example of this invention.

[Drawing 7] Drawing showing change of the impedance characteristic at the time of changing the standardization thickness of SiO₂ film, and a phase characteristic in the manufacture approach of an example.

[Drawing 8] Drawing showing the relation of the thickness of SiO₂ film and γ of a resonator in the surface acoustic wave resonator obtained by the manufacture approach of an example and the example of a comparison.

[Drawing 9] Drawing showing the relation of the thickness of SiO₂ film and MF of a resonator in the surface acoustic wave resonator obtained by the manufacture approach of an example and the example of a comparison.

[Drawing 10] Drawing showing the relation between the thickness of SiO₂ film in the surface acoustic wave resonator prepared in the example and the example of a comparison, and change of the frequency temperature characteristic TCF.

[Drawing 11] Drawing showing the impedance-frequency characteristics which do not have SiO₂ film with the surface acoustic wave resonator in which SiO₂ film prepared in the 2nd example of a comparison was formed.

[Drawing 12] (a) - (e) is drawing showing change of the impedance characteristic at the time of changing the ratio to the consistency of the 1st insulating material layer of the mean density of an IDT electrode and a protection metal membrane.

[Drawing 13] Drawing showing change of the electromechanical coupling

coefficient at the time of forming the IDT electrode which consists of various metals by various thickness on the LiTaO₃ substrate of an Eulerian angle (0 degree, 126 degrees, 0 degree).

[Drawing 14] Drawing showing relation with the consistency of the electrode layer Atsunori enclosure and electrode material with which an electromechanical coupling coefficient becomes large compared with the case where the electrode which consists of aluminum is used when an IDT electrode is formed with various metals on LiTaO₃ substrate.

[Drawing 15] The perspective view showing the surface acoustic wave equipment concerning other examples of this invention.

[Drawing 16] Drawing showing the relation of the electrode layer thickness and the electromechanical coupling coefficient by which IDT at the time of forming IDT which consists of IDT and aluminum which consist of Au, Ta, Ag, Cr, W, Cu, Zn, Mo, and nickel on the LiTaO₃ substrate of 36-degree rotation Y cut X propagation (they are (0 degree, 126 degrees, 0 degree) at an Eulerian angle) was standardized.

[Drawing 17] 36-degree rotation Y cut X propagation (drawing showing the reflection coefficient of electrode finger one of the two of IDT and the relation of thickness it is unrelated from various electrode materials on the LiTaO₃ substrate of (0 degree, 126 degrees, 0 degree) by the Eulerian angle.)

[Drawing 18] Drawing showing the relation between the electrode standardization thickness of IDT at the time of forming IDT which consists of IDT and aluminum which consist of Au, Ta, Ag, Cr, W, Cu, Zn, Mo, and nickel on the LiTaO₃ substrate of 36-degree rotation Y cut X propagation (they are (0 degree, 126 degrees, 0 degree) at an Eulerian angle), and an attenuation coefficient.

[Drawing 19] Drawing showing change of the frequency temperature characteristic (TCF) when standardization thickness forms IDT which consists of Au which is 0.02 and forms SiO₂ film of various thickness on the LiTaO₃ substrate of 36-degree rotation Y cut X propagation (they are (0 degree, 126 degrees, 0 degree) at an Eulerian angle).

[Drawing 20] Drawing showing change of the attenuation coefficient alpha at the time of changing the SiO₂ film standardization thickness which forms IDT which consists of Au of various thickness on the LiTaO₃ substrate of 36-degree rotation Y cut X propagation (they are (0 degree, 126 degrees, 0 degree) at an Eulerian angle), and turns a laminating up further.

[Drawing 21] Drawing showing change of the attenuation coefficient alpha at the time of changing the SiO₂ film standardization thickness which forms IDT which consists of Au of various thickness on the LiTaO₃

substrate of 38-degree rotation Y cut X propagation (they are (0 degree, 128 degrees, 0 degree) at an Eulerian angle), and turns a laminating up further.

[Drawing 22] Drawing showing the magnitude-of-attenuation frequency characteristics of the surface acoustic wave equipment for the comparison before the magnitude-of-attenuation frequency characteristics of the surface acoustic wave equipment of an example, and SiO₂ film membrane formation.

[Drawing 23] Drawing showing change of the acoustic velocity of the leakage surface acoustic wave at the time of changing the standardization thickness of IDT which consists of Au in the structure which formed IDT which consists of Au and formed SiO₂ film of various thickness on the LiTaO₃ substrate of 36-degree rotation Y cut X propagation (they are (0 degree, 126 degrees, 0 degree) at an Eulerian angle).

[Drawing 24] Drawing showing change of the acoustic velocity of the leakage surface acoustic wave at the time of changing the standardization thickness of SiO₂ film in the structure which formed IDT which consists of Au of various standardization thickness on the LiTaO₃ substrate of 36-degree rotation Y cut X propagation (they are (0 degree, 126 degrees, 0 degree) at an Eulerian angle), and was further made into the SiO₂ film laminating.

[Drawing 25] Drawing showing change of the electromechanical coupling coefficient at the time of changing the standardization thickness of IDT which consists of theta of (0 degree, theta, 0 degree), and Au by the Eulerian angle, and the standardization thickness of SiO₂ film.

[Drawing 26] Drawing showing change of the Q value of the resonator at the time of changing theta of the Eulerian angle of LiTaO₃ substrate, and the standardization thickness of SiO₂ film.

[Drawing 27] (a) - (c) is each typical sectional view for explaining the surface acoustic wave equipment concerning the modification of this invention in which the adhesion layer was prepared.

[Drawing 28] Thickness H/λ of SiO₂ film = drawing showing the relation of the attenuation coefficients alpha and theta in various Au electrode layer thickness in 0.1.

[Drawing 29] Thickness H/λ of SiO₂ film = drawing showing the relation of the attenuation coefficients alpha and theta in various Au electrode layer thickness in 0.15.

[Drawing 30] Thickness H/λ of SiO₂ film = drawing showing the relation of the attenuation coefficients alpha and theta in various Au electrode layer thickness in 0.2.

[Drawing 31] Thickness H/λ of SiO₂ film = drawing showing the relation of the attenuation coefficients α and θ in various Au electrode layer thickness in 0.25.

[Drawing 32] Thickness H/λ of SiO₂ film = drawing showing the relation of the attenuation coefficients α and θ in various Au electrode layer thickness in 0.3.

[Drawing 33] Thickness H/λ of SiO₂ film = drawing showing the relation of the attenuation coefficients α and θ in various Au electrode layer thickness in 0.35.

[Drawing 34] Thickness H/λ of SiO₂ film = drawing showing the relation of the attenuation coefficients α and θ in various Au electrode layer thickness in 0.4.

[Drawing 35] Thickness H/λ of SiO₂ film = drawing showing the relation of the attenuation coefficients α and θ in various Au electrode layer thickness in 0.45.

[Drawing 36] Drawing showing relation with an electromechanical coupling coefficient K_{SAW} with standardization thickness H/λ of Ag film at the time of forming the electrode which consists of Ag film of various thickness on the LiTaO₃ substrate of an Eulerian angle (0 degree, 126 degrees, 0 degree).

[Drawing 37] an Eulerian angle (0 degree, 113 degrees, 0 degree) -- and (0 degree, 126 degrees, 0 degree) (0 degree, 129 degrees, 0 degree) drawing showing the relation between standardization thickness H_s/λ of SiO₂ film when electrode layer thickness forms SiO₂ film of various thickness by 0, and the frequency temperature coefficient TCF in three kinds of LiTaO₃ substrates.

[Drawing 38] Drawing showing change of the attenuation coefficient α at the time of forming Ag film of 0.1 or less standardization thickness on the LiTaO₃ substrate of an Eulerian angle (0 degree, 120 degrees, 0 degree), and forming SiO₂ film of the standardization thickness of 0-0.5.

[Drawing 39] Drawing showing change of the attenuation coefficient α at the time of forming Ag film of 0.1 or less standardization thickness on the LiTaO₃ substrate of an Eulerian angle (0 degree, 140 degrees, 0 degree), and forming SiO₂ film of the standardization thickness of 0-0.5.

[Drawing 40] Drawing showing change of an attenuation coefficient α when standardization thickness H/λ forms 0.1 or less various Ag film on the LiTaO₃ substrate of an Eulerian angle (0 degree, θ , 0 degree) and standardization thickness H_s/λ carries out the laminating of the SiO₂ film of 0.1.

[Drawing 41] Drawing showing change of an attenuation coefficient α when standardization thickness H/λ forms 0.1 or less various Ag

film on the LiTaO₃ substrate of an Eulerian angle (0 degree, θ , 0 degree) and standardization thickness H_s/λ carries out the laminating of the SiO₂ film of 0.15.

[Drawing 42] Drawing showing change of an attenuation coefficient α when standardization thickness H/λ forms 0.1 or less various Ag film on the LiTaO₃ substrate of an Eulerian angle (0 degree, θ , 0 degree) and standardization thickness H_s/λ carries out the laminating of the SiO₂ film of 0.2.

[Drawing 43] Drawing showing change of an attenuation coefficient α when standardization thickness H/λ forms 0.1 or less various Ag film on the LiTaO₃ substrate of an Eulerian angle (0 degree, θ , 0 degree) and standardization thickness H_s/λ carries out the laminating of the SiO₂ film of 0.25.

[Drawing 44] Drawing showing change of an attenuation coefficient α when standardization thickness H/λ forms 0.1 or less various Ag film on the LiTaO₃ substrate of an Eulerian angle (0 degree, θ , 0 degree) and standardization thickness H_s/λ carries out the laminating of the SiO₂ film of 0.3.

[Drawing 45] Drawing showing change of an attenuation coefficient α when standardization thickness H/λ forms 0.1 or less various Ag film on the LiTaO₃ substrate of an Eulerian angle (0 degree, θ , 0 degree) and standardization thickness H_s/λ carries out the laminating of the SiO₂ film of 0.35.

[Drawing 46] Drawing showing change of an attenuation coefficient α when standardization thickness H/λ forms 0.1 or less various Ag film on the LiTaO₃ substrate of an Eulerian angle (0 degree, θ , 0 degree) and standardization thickness H_s/λ carries out the laminating of the SiO₂ film of 0.4.

[Drawing 47] Drawing showing change of an attenuation coefficient α when standardization thickness H/λ forms 0.1 or less various Ag film on the LiTaO₃ substrate of an Eulerian angle (0 degree, θ , 0 degree) and standardization thickness H_s/λ carries out the laminating of the SiO₂ film of 0.45.

[Drawing 48] Drawing showing change of the attenuation coefficient α at the time of forming Cu film of 0.1 or less standardization thickness on the LiTaO₃ substrate of an Eulerian angle (0 degree, 120 degrees, 0 degree), and forming SiO₂ film of the standardization thickness of 0–0.5.

[Drawing 49] Drawing showing change of the attenuation coefficient α at the time of forming Cu film of 0.1 or less standardization thickness on the LiTaO₃ substrate of an Eulerian angle (0 degree, 135 degrees, 0 degree), and forming SiO₂ film of the standardization thickness of 0–0.5.

[Drawing 50] Drawing showing change of an attenuation coefficient α when standardization thickness H/λ forms 0.1 or less various Cu film on the LiTaO₃ substrate of an Eulerian angle (0 degree, θ , 0 degree) and standardization thickness H_s/λ carries out the laminating of the SiO₂ film of 0.1.

[Drawing 51] Drawing showing change of an attenuation coefficient α when standardization thickness H/λ forms 0.1 or less various Cu film on the LiTaO₃ substrate of an Eulerian angle (0 degree, θ , 0 degree) and standardization thickness H_s/λ carries out the laminating of the SiO₂ film of 0.15.

[Drawing 52] Drawing showing change of an attenuation coefficient α when standardization thickness H/λ forms 0.1 or less various Cu film on the LiTaO₃ substrate of an Eulerian angle (0 degree, θ , 0 degree) and standardization thickness H_s/λ carries out the laminating of the SiO₂ film of 0.2.

[Drawing 53] Drawing showing change of an attenuation coefficient α when standardization thickness H/λ forms 0.1 or less various Cu film on the LiTaO₃ substrate of an Eulerian angle (0 degree, θ , 0 degree) and standardization thickness H_s/λ carries out the laminating of the SiO₂ film of 0.25.

[Drawing 54] Drawing showing change of an attenuation coefficient α when standardization thickness H/λ forms 0.1 or less various Cu film on the LiTaO₃ substrate of an Eulerian angle (0 degree, θ , 0 degree) and standardization thickness H_s/λ carries out the laminating of the SiO₂ film of 0.3.

[Drawing 55] Drawing showing change of an attenuation coefficient α when standardization thickness H/λ forms 0.1 or less various Cu film on the LiTaO₃ substrate of an Eulerian angle (0 degree, θ , 0 degree) and standardization thickness H_s/λ carries out the laminating of the SiO₂ film of 0.35.

[Drawing 56] Drawing showing change of an attenuation coefficient α when standardization thickness H/λ forms 0.1 or less various Cu film on the LiTaO₃ substrate of an Eulerian angle (0 degree, θ , 0 degree) and standardization thickness H_s/λ carries out the laminating of the SiO₂ film of 0.4.

[Drawing 57] Drawing showing change of an attenuation coefficient α when standardization thickness H/λ forms 0.1 or less various Cu film on the LiTaO₃ substrate of an Eulerian angle (0 degree, θ , 0 degree) and standardization thickness H_s/λ carries out the laminating of the SiO₂ film of 0.45.

[Drawing 58] Drawing showing the relation of the reflection factor per

electrode finger and electrode layer thickness in the electrode which consists of an electrode which consists of aluminum in case the standardization thickness of SiO₂ film is 0.02, and Cu.

[Drawing 59] Drawing showing the relation between standardization thickness H_s/λ of SiO₂ film for realizing the θ from which an attenuation coefficient serves as 0 or min, and standardization thickness H/λ of Cu film.

[Drawing 60] Drawing showing change of the attenuation coefficient α in the structure in which IDT which consists of SiO₂ film of various thickness and a tungsten of various thickness was formed on the LiTaO₃ substrate of an Eulerian angle (0 degree, 120 degrees, 0 degree).

[Drawing 61] Drawing showing change of the attenuation coefficient α in the structure in which IDT which consists of SiO₂ film of various thickness and a tungsten of various thickness was formed on the LiTaO₃ substrate of an Eulerian angle (0 degree, 140 degrees, 0 degree).

[Drawing 62] Drawing showing relation with an attenuation coefficient α with θ in the surface acoustic wave equipment which formed the electrode layer which consists of a tungsten of various thickness, and formed SiO₂ film of standardization thickness $H_s/\lambda = 0.1$ further on the LiTaO₃ substrate of an Eulerian angle (0 degree, θ , 0 degree), and standardization thickness H/λ of the electrode layer which consists of a tungsten.

[Drawing 63] Drawing showing relation with an attenuation coefficient α with θ in the surface acoustic wave equipment which formed the electrode layer which consists of a tungsten of various thickness, and formed SiO₂ film of standardization thickness $H_s/\lambda = 0.2$ further on the LiTaO₃ substrate of an Eulerian angle (0 degree, θ , 0 degree), and standardization thickness H/λ of the electrode layer which consists of a tungsten.

[Drawing 64] Drawing showing relation with an attenuation coefficient α with θ in the surface acoustic wave equipment which formed the electrode layer which consists of a tungsten of various thickness, and formed SiO₂ film of standardization thickness $H_s/\lambda = 0.3$ further on the LiTaO₃ substrate of an Eulerian angle (0 degree, θ , 0 degree), and standardization thickness H/λ of the electrode layer which consists of a tungsten.

[Drawing 65] Drawing showing relation with an attenuation coefficient α with θ in the surface acoustic wave equipment which formed the electrode layer which consists of a tungsten of various thickness, and formed SiO₂ film of standardization thickness $H_s/\lambda = 0.4$ further on the LiTaO₃ substrate of an Eulerian angle (0 degree, θ , 0 degree),

and standardization thickness H/λ of the electrode layer which consists of a tungsten.

[Drawing 66] Drawing showing the thickness of the tungsten film at the time of forming IDT which consists of a tungsten and forming SiO₂ film further on the LiTaO₃ substrate of an Eulerian angle (0 degree, 126 degrees, 0 degree), the thickness of SiO₂ film, and relation with acoustic velocity.

[Drawing 67] Drawing showing the thickness of the tungsten film at the time of forming IDT which consists of a tungsten and forming SiO₂ film further on the LiTaO₃ substrate of an Eulerian angle (0 degree, 126 degrees, 0 degree), the thickness of SiO₂ film, and relation with acoustic velocity.

[Drawing 68] Drawing showing change of the attenuation coefficient α in the structure in which IDT which consists of a tantalum of SiO₂ film of various thickness and various thickness was formed on the LiTaO₃ substrate of an Eulerian angle (0 degree, 120 degrees, 0 degree).

[Drawing 69] Drawing showing change of the attenuation coefficient α in the structure in which IDT which consists of a tantalum of SiO₂ film of various thickness and various thickness was formed on the LiTaO₃ substrate of an Eulerian angle (0 degree, 140 degrees, 0 degree).

[Drawing 70] Drawing showing relation with an attenuation coefficient α with θ in the surface acoustic wave equipment which formed the electrode layer which consists of a tantalum of various thickness, and formed SiO₂ film of standardization thickness $H_s/\lambda = 0.1$ further on the LiTaO₃ substrate of an Eulerian angle (0 degree, θ , 0 degree), and standardization thickness H/λ of the electrode layer which consists of a tantalum.

[Drawing 71] Drawing showing relation with an attenuation coefficient α with θ in the surface acoustic wave equipment which formed the electrode layer which consists of a tantalum of various thickness, and formed SiO₂ film of standardization thickness $H_s/\lambda = 0.2$ further on the LiTaO₃ substrate of an Eulerian angle (0 degree, θ , 0 degree), and standardization thickness H/λ of the electrode layer which consists of a tantalum.

[Drawing 72] Drawing showing relation with an attenuation coefficient α with θ in the surface acoustic wave equipment which formed the electrode layer which consists of a tantalum of various thickness, and formed SiO₂ film of standardization thickness $H_s/\lambda = 0.3$ further on the LiTaO₃ substrate of an Eulerian angle (0 degree, θ , 0 degree), and standardization thickness H/λ of the electrode layer which consists of a tantalum.

[Drawing 73] Drawing showing relation with an attenuation coefficient α with θ in the surface acoustic wave equipment which formed the electrode layer which consists of a tantalum of various thickness, and formed SiO₂ film of standardization thickness $H_s/\lambda = 0.4$ further on the LiTaO₃ substrate of an Eulerian angle (0 degree, θ , 0 degree), and standardization thickness H/λ of the electrode layer which consists of a tantalum.

[Drawing 74] Drawing showing relation with acoustic velocity with the standardization thickness of a tantalum in the structure which formed IDT which consists of a tantalum on the LiTaO₃ substrate of an Eulerian angle (0 degree, 126 degrees, 0 degree), and formed SiO₂ film on it, and the standardization thickness of SiO₂.

[Drawing 75] Drawing showing relation with acoustic velocity with the standardization thickness of a tantalum in the structure where IDT which consists of a tantalum is formed on the LiTaO₃ substrate of an Eulerian angle (0 degree, 126 degrees, 0 degree), and SiO₂ film was formed on it, and the standardization thickness of SiO₂.

[Drawing 76] Drawing showing change of the attenuation coefficient α in the structure in which IDT which consists of SiO₂ film of various thickness and platinum of various thickness was formed on the LiTaO₃ substrate of an Eulerian angle (0 degree, 125 degrees, 0 degree).

[Drawing 77] Drawing showing change of the attenuation coefficient α in the structure in which IDT which consists of SiO₂ film of various thickness and platinum of various thickness was formed on the LiTaO₃ substrate of an Eulerian angle (0 degree, 140 degrees, 0 degree).

[Drawing 78] Drawing showing relation with an attenuation coefficient α with θ in the surface acoustic wave equipment which formed the electrode layer which consists of platinum of various thickness, and formed SiO₂ film of standardization thickness $H_s/\lambda = 0.1$ further on the LiTaO₃ substrate of an Eulerian angle (0 degree, θ , 0 degree), and standardization thickness H/λ of the electrode layer which consists of platinum.

[Drawing 79] Drawing showing relation with an attenuation coefficient α with θ in the surface acoustic wave equipment which formed the electrode layer which consists of platinum of various thickness, and formed SiO₂ film of standardization thickness $H_s/\lambda = 0.15$ further on the LiTaO₃ substrate of an Eulerian angle (0 degree, θ , 0 degree), and standardization thickness H/λ of the electrode layer which consists of platinum.

[Drawing 80] Drawing showing relation with an attenuation coefficient α with θ in the surface acoustic wave equipment which formed the

electrode layer which consists of platinum of various thickness, and formed SiO₂ film of standardization thickness $H_s/\lambda = 0.2$ further on the LiTaO₃ substrate of an Eulerian angle (0 degree, θ , 0 degree), and standardization thickness H/λ of the electrode layer which consists of platinum.

[Drawing 81] Drawing showing relation with an attenuation coefficient α with θ in the surface acoustic wave equipment which formed the electrode layer which consists of platinum of various thickness, and formed SiO₂ film of standardization thickness $H_s/\lambda = 0.25$ further on the LiTaO₃ substrate of an Eulerian angle (0 degree, θ , 0 degree), and standardization thickness H/λ of the electrode layer which consists of platinum.

[Drawing 82] Drawing showing relation with an attenuation coefficient α with θ in the surface acoustic wave equipment which formed the electrode layer which consists of platinum of various thickness, and formed SiO₂ film of standardization thickness $H_s/\lambda = 0.3$ further on the LiTaO₃ substrate of an Eulerian angle (0 degree, θ , 0 degree), and standardization thickness H/λ of the electrode layer which consists of platinum.

[Drawing 83] Drawing showing relation with an attenuation coefficient α with θ in the surface acoustic wave equipment which formed the electrode layer which consists of platinum of various thickness, and formed SiO₂ film of standardization thickness $H_s/\lambda = 0.4$ further on the LiTaO₃ substrate of an Eulerian angle (0 degree, θ , 0 degree), and standardization thickness H/λ of the electrode layer which consists of platinum.

[Drawing 84] Drawing showing the thickness of the platinum film at the time of forming IDT which consists of platinum and forming SiO₂ film further on the LiTaO₃ substrate of an Eulerian angle (0 degree, 126 degrees, 0 degree), the thickness of SiO₂ film, and relation with acoustic velocity.

[Drawing 85] Drawing showing the thickness of the platinum film at the time of forming IDT which consists of platinum and forming SiO₂ film further on the LiTaO₃ substrate of an Eulerian angle (0 degree, 126 degrees, 0 degree), the thickness of SiO₂ film, and relation with acoustic velocity.

[Drawing 86] Drawing showing change of the attenuation coefficient α in the structure in which IDT which consists of SiO₂ film of various thickness and nickel of various thickness was formed on the LiTaO₃ substrate of an Eulerian angle (0 degree, 120 degrees, 0 degree).

[Drawing 87] Drawing showing change of the attenuation coefficient α

in the structure in which IDT which consists of SiO₂ film of various thickness and nickel of various thickness was formed on the LiTaO₃ substrate of an Eulerian angle (0 degree, 140 degrees, 0 degree).

[Drawing 88] Drawing showing change of the attenuation coefficient α in the structure in which IDT which consists of SiO₂ film of various thickness and molybdenum of various thickness was formed on the LiTaO₃ substrate of an Eulerian angle (0 degree, 120 degrees, 0 degree).

[Drawing 89] Drawing showing change of the attenuation coefficient α in the structure in which IDT which consists of SiO₂ film of various thickness and molybdenum of various thickness was formed on the LiTaO₃ substrate of an Eulerian angle (0 degree, 140 degrees, 0 degree).

[Drawing 90] Drawing showing relation with an attenuation coefficient α with θ in the surface acoustic wave equipment which formed the electrode layer which consists of nickel of various thickness, and formed SiO₂ film of standardization thickness $H_s/\lambda = 0.1$ further on the LiTaO₃ substrate of an Eulerian angle (0 degree, θ , 0 degree), and standardization thickness H/λ of the electrode layer which consists of nickel.

[Drawing 91] Drawing showing relation with an attenuation coefficient α with θ in the surface acoustic wave equipment which formed the electrode layer which consists of nickel of various thickness, and formed SiO₂ film of standardization thickness $H_s/\lambda = 0.2$ further on the LiTaO₃ substrate of an Eulerian angle (0 degree, θ , 0 degree), and standardization thickness H/λ of the electrode layer which consists of nickel.

[Drawing 92] Drawing showing relation with an attenuation coefficient α with θ in the surface acoustic wave equipment which formed the electrode layer which consists of nickel of various thickness, and formed SiO₂ film of standardization thickness $H_s/\lambda = 0.3$ further on the LiTaO₃ substrate of an Eulerian angle (0 degree, θ , 0 degree), and standardization thickness H/λ of the electrode layer which consists of nickel.

[Drawing 93] Drawing showing relation with an attenuation coefficient α with θ in the surface acoustic wave equipment which formed the electrode layer which consists of nickel of various thickness, and formed SiO₂ film of standardization thickness $H_s/\lambda = 0.4$ further on the LiTaO₃ substrate of an Eulerian angle (0 degree, θ , 0 degree), and standardization thickness H/λ of the electrode layer which consists of nickel.

[Drawing 94] Drawing showing relation with an attenuation coefficient α with θ in the surface acoustic wave equipment which formed the

electrode layer which consists of molybdenum of various thickness, and formed SiO₂ film of standardization thickness $H_s/\lambda = 0.1$ further on the LiTaO₃ substrate of an Eulerian angle (0 degree, θ , 0 degree), and standardization thickness H/λ of the electrode layer which consists of molybdenum.

[Drawing 95] Drawing showing relation with an attenuation coefficient α with θ in the surface acoustic wave equipment which formed the electrode layer which consists of molybdenum of various thickness, and formed SiO₂ film of standardization thickness $H_s/\lambda = 0.2$ further on the LiTaO₃ substrate of an Eulerian angle (0 degree, θ , 0 degree), and standardization thickness H/λ of the electrode layer which consists of molybdenum.

[Drawing 96] Drawing showing relation with an attenuation coefficient α with θ in the surface acoustic wave equipment which formed the electrode layer which consists of molybdenum of various thickness, and formed SiO₂ film of standardization thickness $H_s/\lambda = 0.3$ further on the LiTaO₃ substrate of an Eulerian angle (0 degree, θ , 0 degree), and standardization thickness H/λ of the electrode layer which consists of molybdenum.

[Drawing 97] Drawing showing relation with an attenuation coefficient α with θ in the surface acoustic wave equipment which formed the electrode layer which consists of molybdenum of various thickness, and formed SiO₂ film of standardization thickness $H_s/\lambda = 0.4$ further on the LiTaO₃ substrate of an Eulerian angle (0 degree, θ , 0 degree), and standardization thickness H/λ of the electrode layer which consists of molybdenum.

[Drawing 98] Drawing showing the thickness of the nickel film when IDT which consists of nickel is formed on the LiTaO₃ substrate of an Eulerian angle (0 degree, 126 degrees, 0 degree) and SiO₂ film of still more various thickness is formed, the thickness of the nickel film, and relation with acoustic velocity.

[Drawing 99] Drawing in which forming IDT which consists of nickel of various thickness on the LiTaO₃ substrate of an Eulerian angle (0 degree, 126 degrees, 0 degree), forming SiO₂ film on it, and showing the thickness of SiO₂ film in structure, and relation with acoustic velocity.

[Drawing 100] Drawing showing relation with acoustic velocity with the standardization thickness of the molybdenum in structure when IDT which becomes since it consists of molybdenum is formed on the LiTaO₃ substrate of an Eulerian angle (0 degree, 126 degrees, 0 degree) and SiO₂ film of various thickness is formed on it.

[Drawing 101] Drawing showing relation with acoustic velocity with the

standardization thickness of SiO₂ film in the structure which formed IDT which consists of molybdenum of various thickness, and formed SiO₂ film further on the LiTaO₃ substrate of an Eulerian angle (0 degree, 126 degrees, 0 degree).

[Drawing 102] (a) - (c) is each typical sectional view for explaining the etchback method as an example of an approach which attains flattening of an insulating material layer front face.

[Drawing 103] (a) - (d) is each typical sectional view for explaining the reverse sputter as other examples of the approach of carrying out flattening of the insulating material layer front face.

[Drawing 104] (a) And (b) is the typical sectional view showing the example of further others of the approach of carrying out flattening of the insulating material layer front face.

[Drawing 105] (a) - (c) is each typical sectional view for explaining an option to the pan which carries out flattening of the insulating material layer front face.

[Drawing 106] (a) And (b) is each typical top view for explaining 1 port mold resonator as an example of surface acoustic wave equipment and 2 port mold resonator to which this invention is applied.

[Drawing 107] The typical top view for explaining the ladder mold filter as surface acoustic wave equipment with which this invention is applied.

[Drawing 108] The typical top view for explaining the lattice mold filter as surface acoustic wave equipment with which this invention is applied.

[Drawing 109] (a) - (d) is a typical sectional view to show an example of the manufacture approach of conventional surface acoustic wave equipment.

[Drawing 110] The typical transverse-plane sectional view for explaining an example of conventional surface acoustic wave equipment. .

[Description of Notations]

- 1 -- LiTaO₃ substrate
- 2 -- The 1st insulating material layer
- 3 -- Resist pattern
- 4 -- Metal membrane
- Four A--IDT electrodes
- 5 -- Ti film as a protection metal membrane
- 6 -- The 2nd insulating material layer
- 11 -- Surface acoustic wave resonator
- 12 13 -- Reflector
- 21 -- Surface acoustic wave equipment
- 22 -- LiTaO₃ substrate

23a, 23 b--IDT
25 -- SiO₂ film

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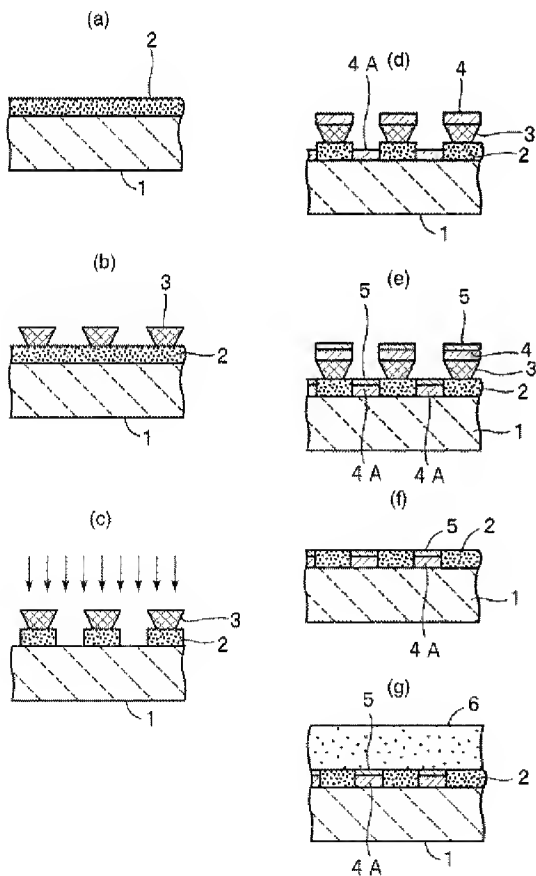
* NOTICES *

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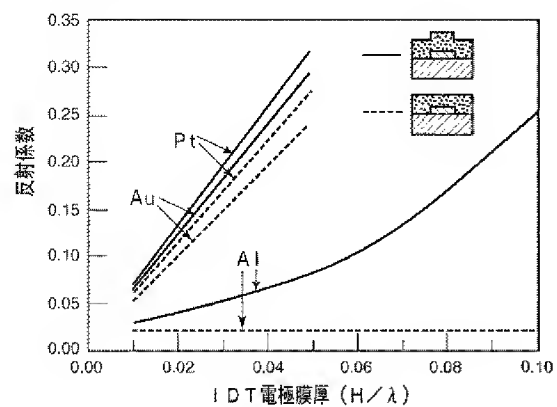
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2. **** shows the word which can not be translated.
3. In the drawings, any words are not translated.

DRAWINGS

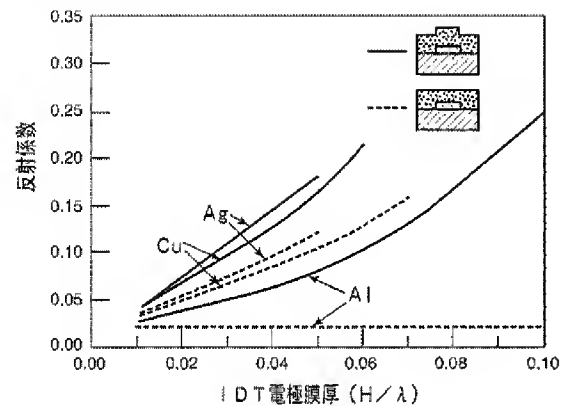
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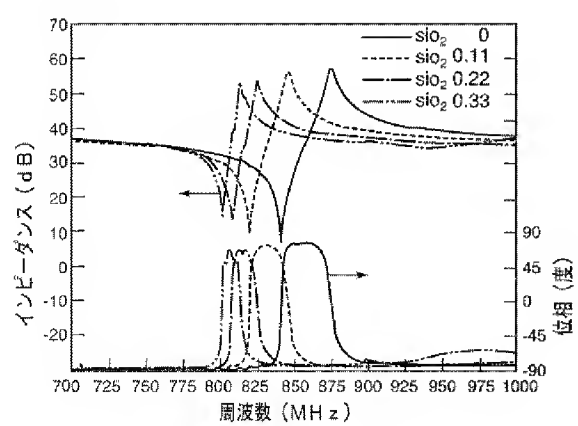
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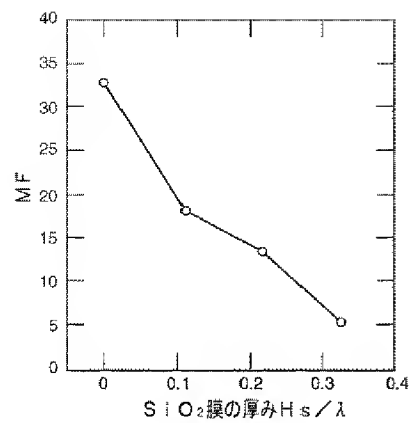
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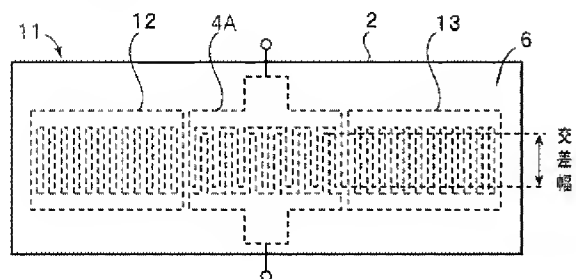
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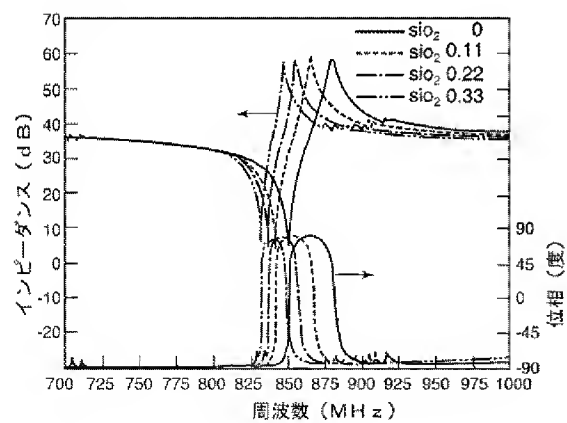
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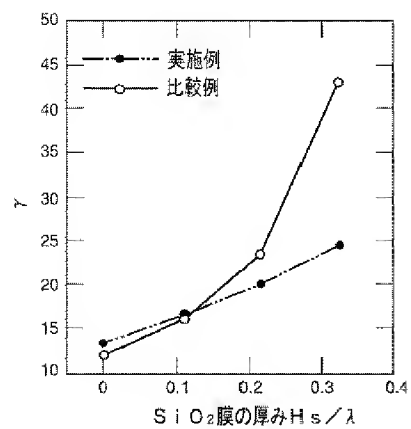
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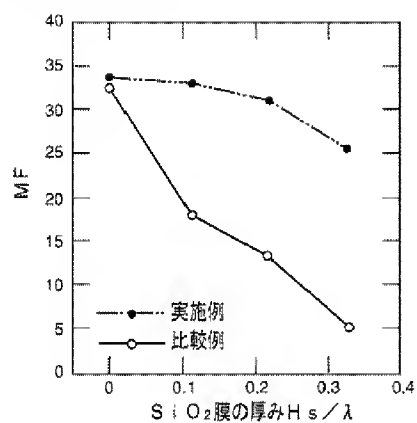
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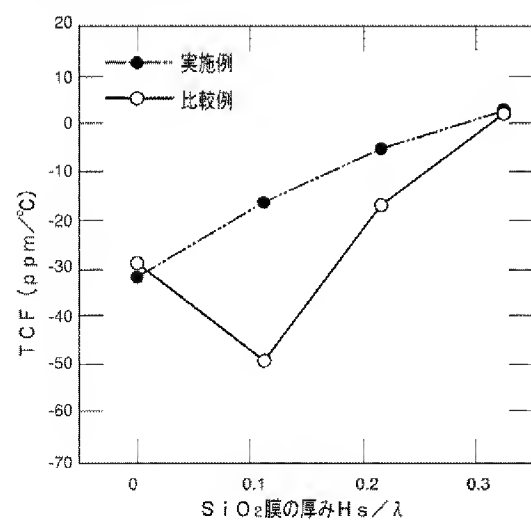
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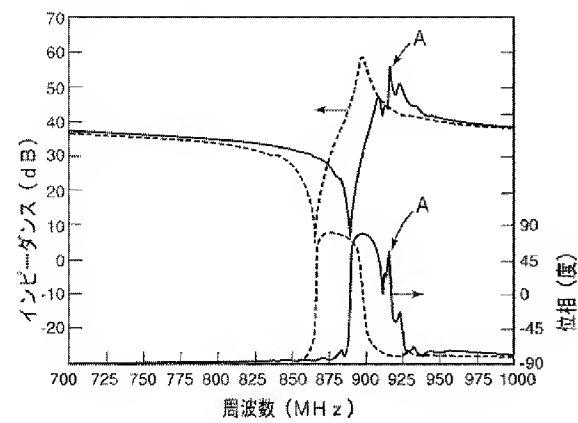
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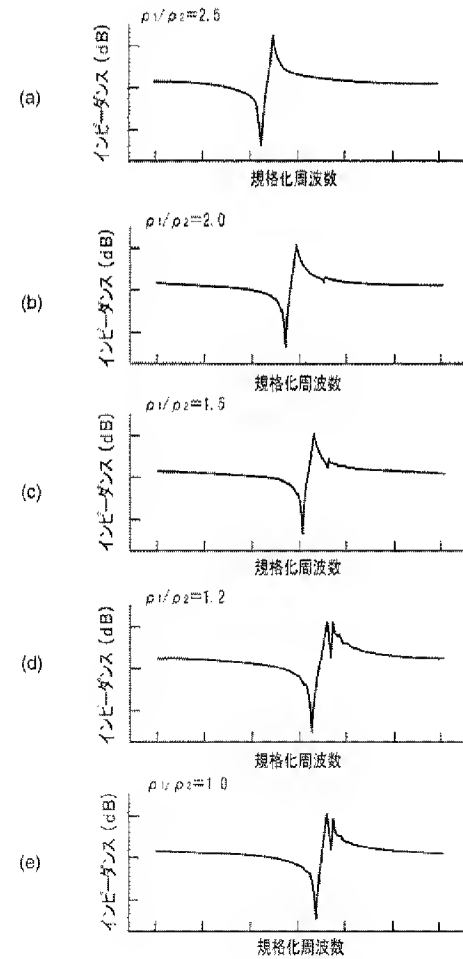
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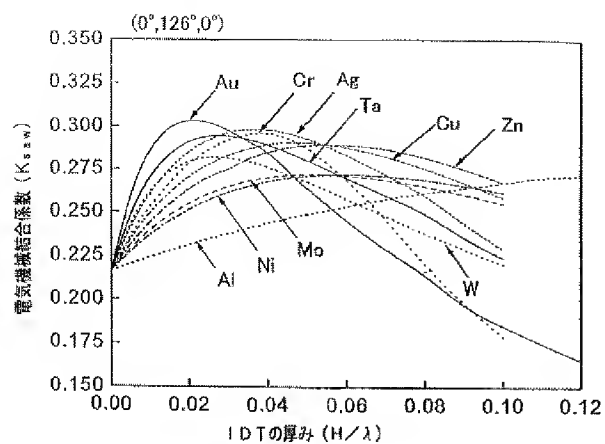
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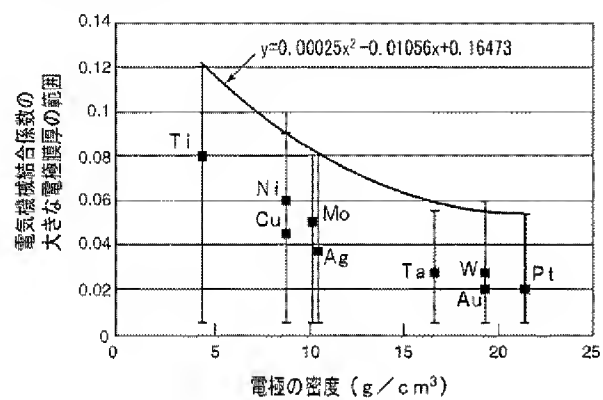
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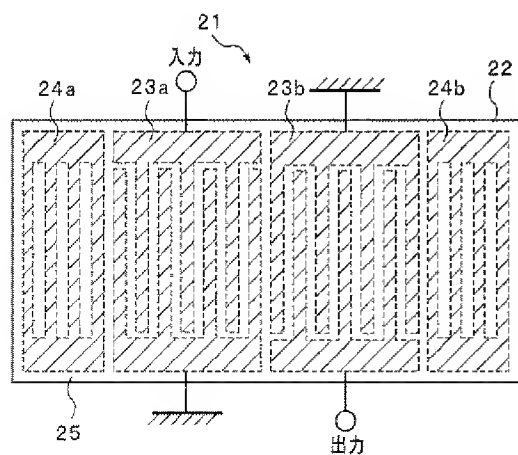
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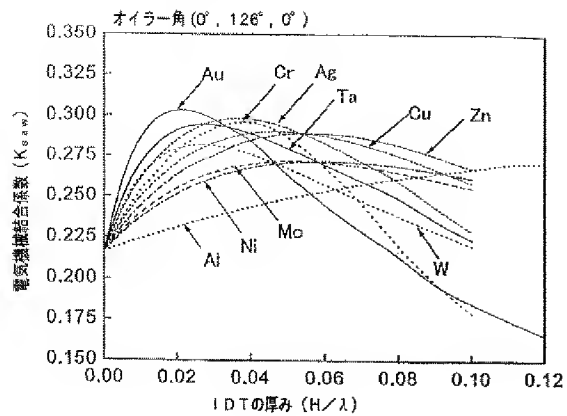
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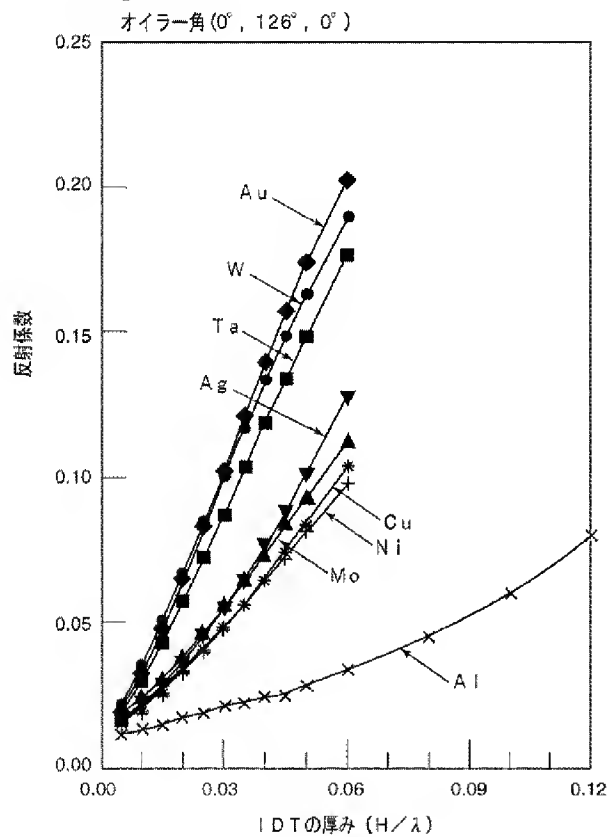
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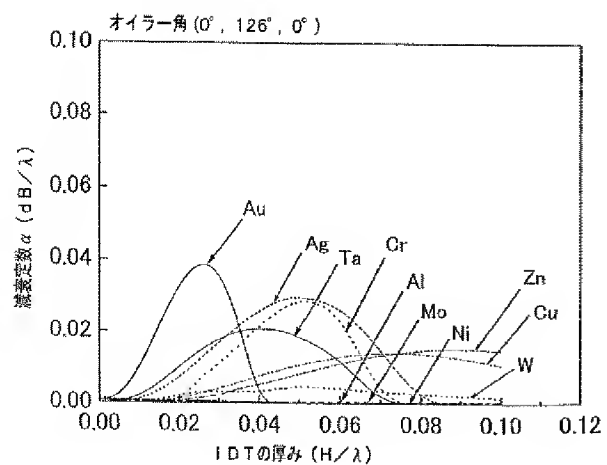
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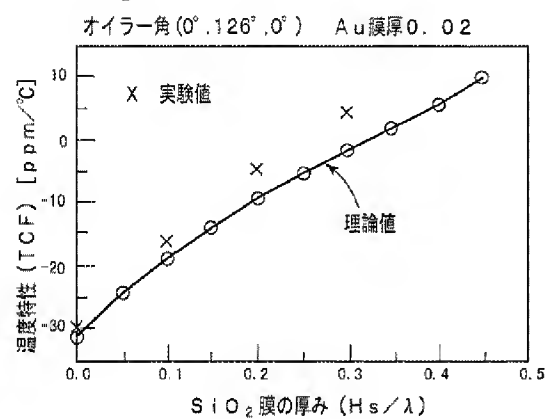
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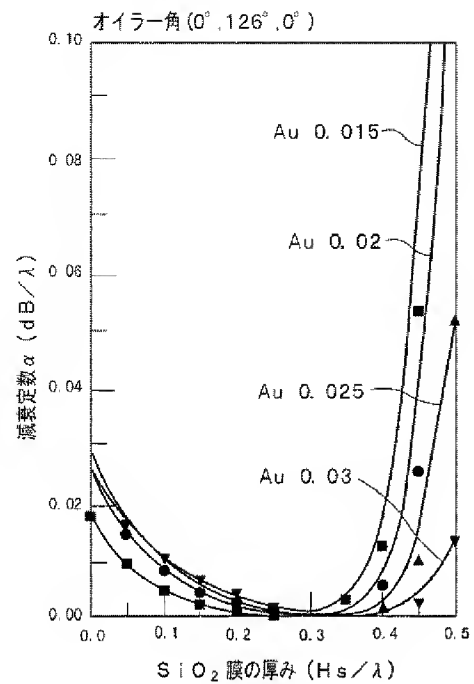
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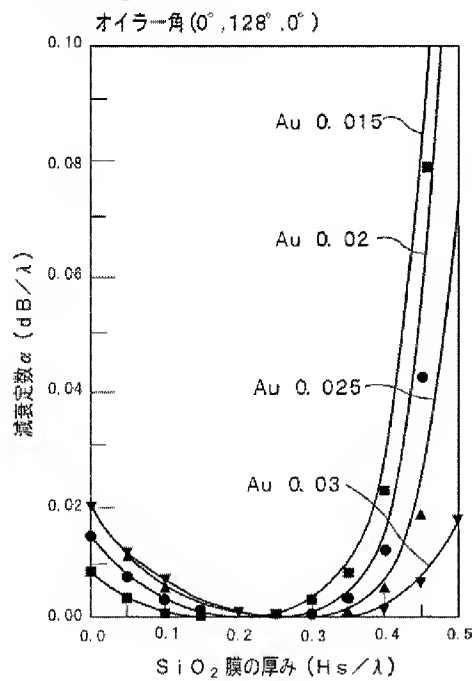
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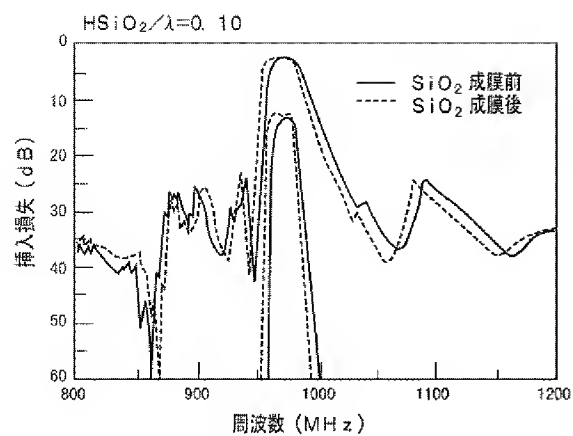
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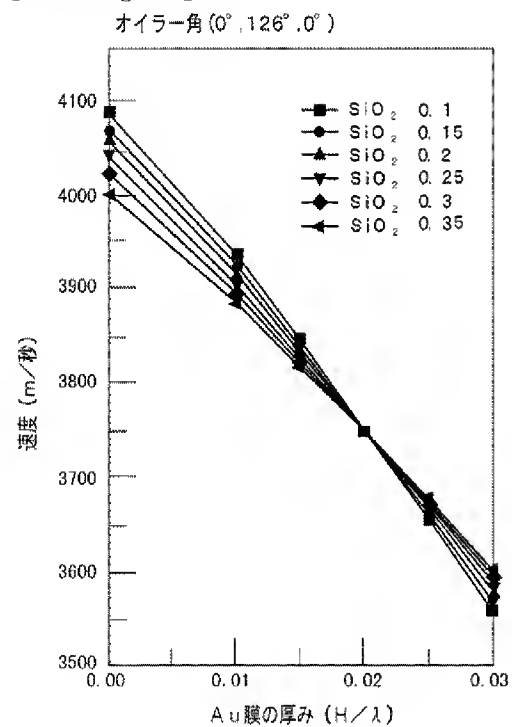
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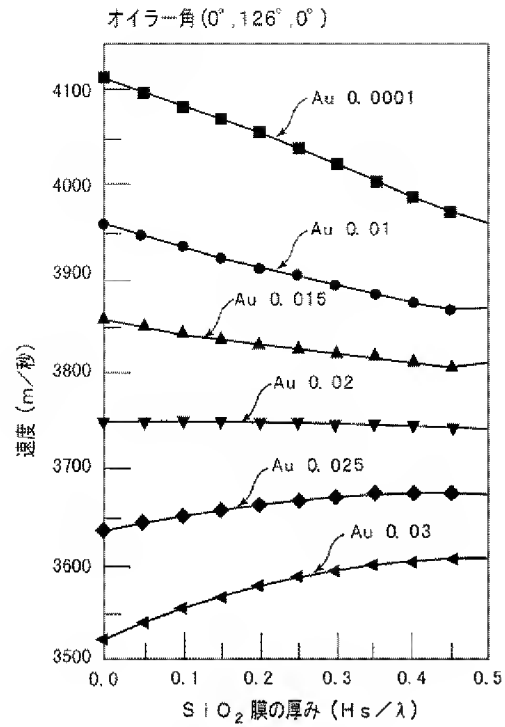
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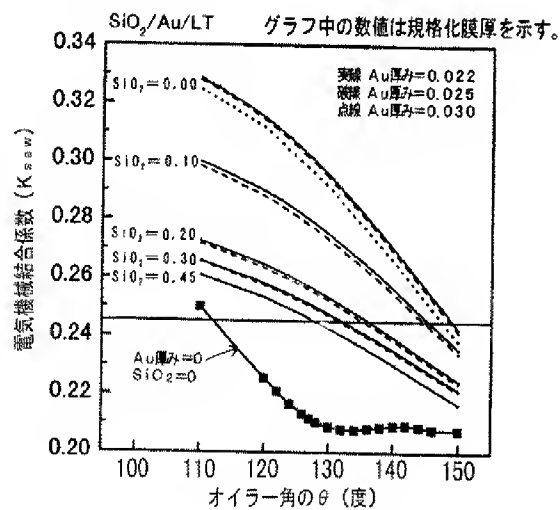
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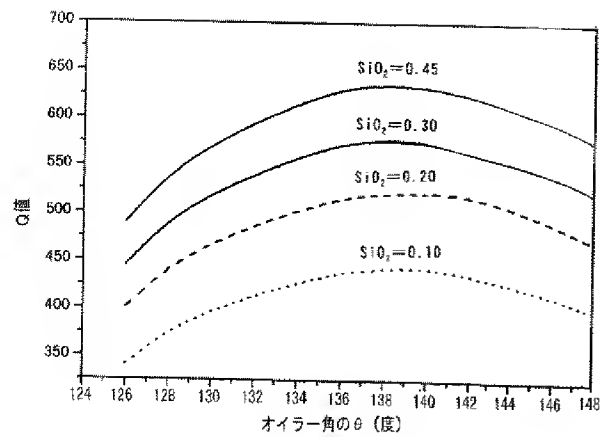
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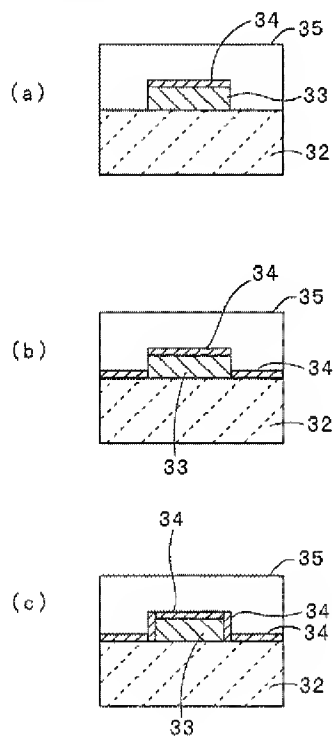
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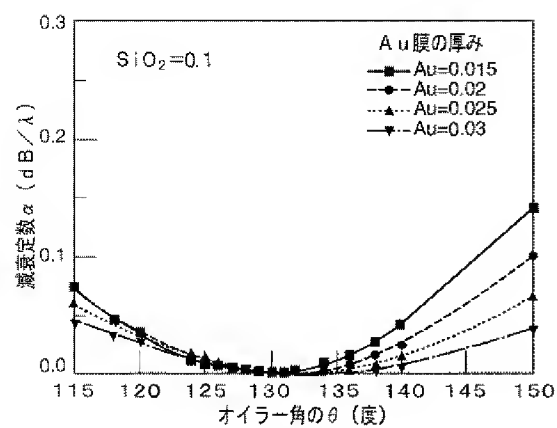
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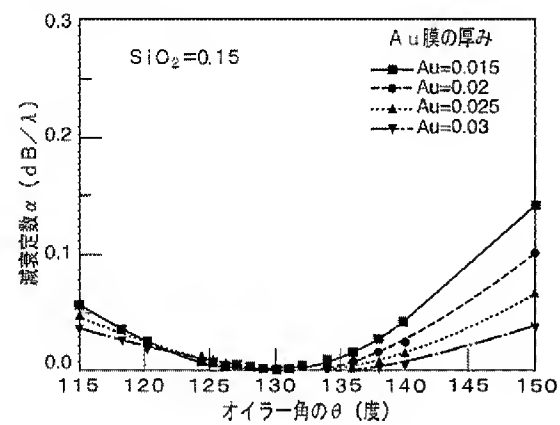
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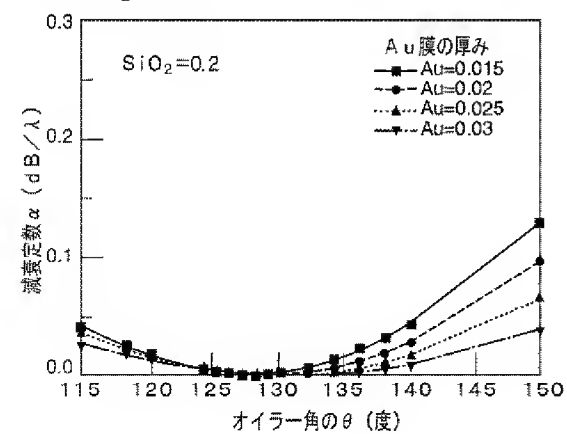
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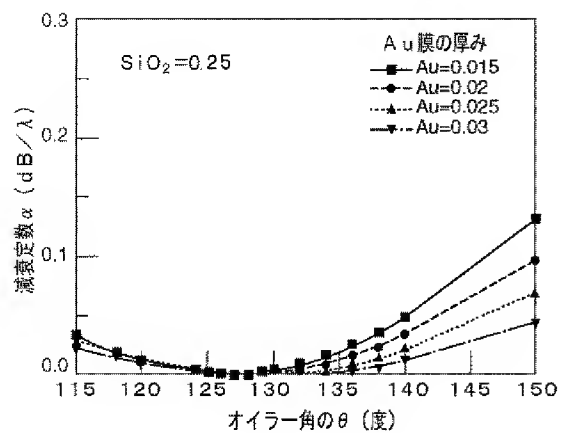
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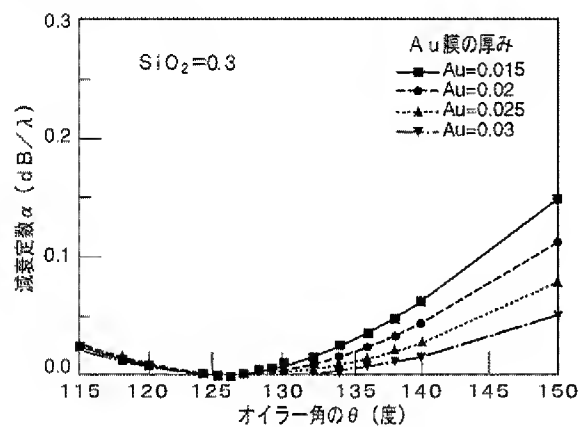
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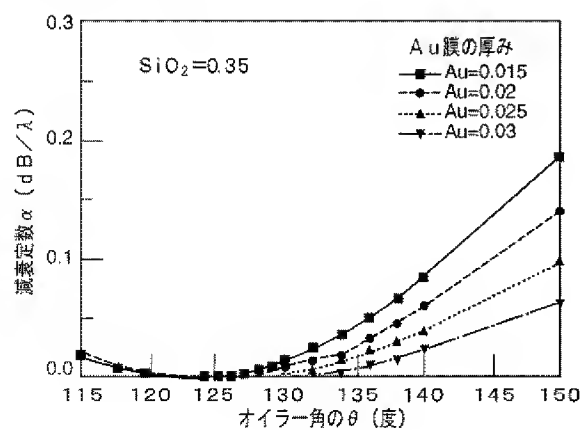
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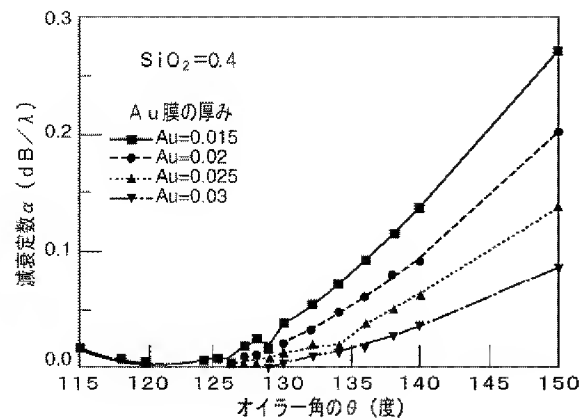
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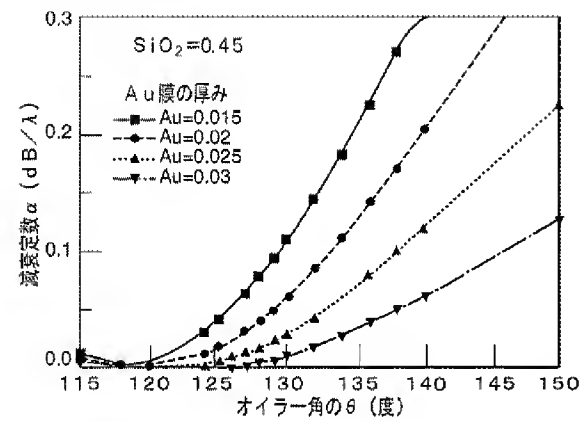
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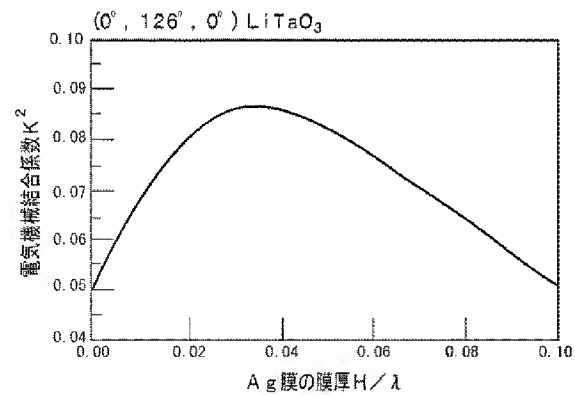
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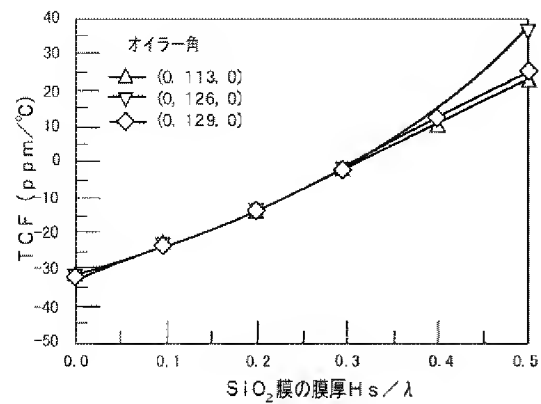
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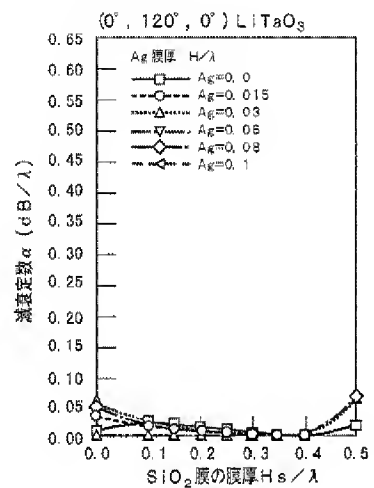
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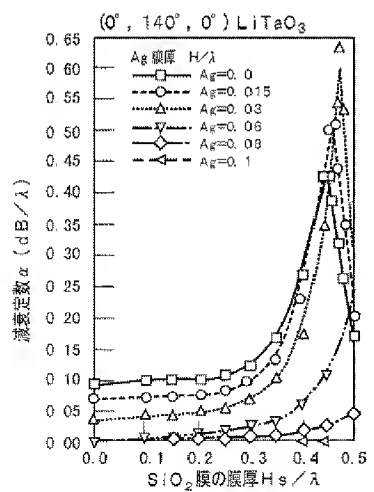
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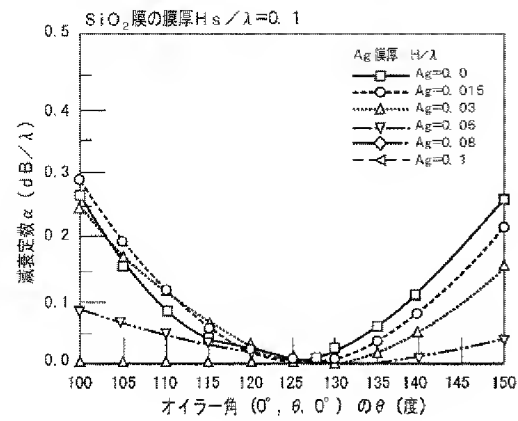
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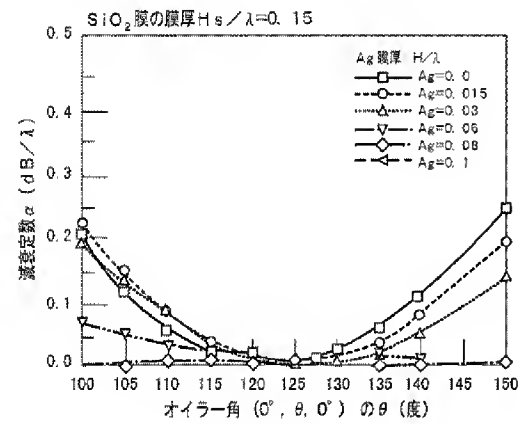
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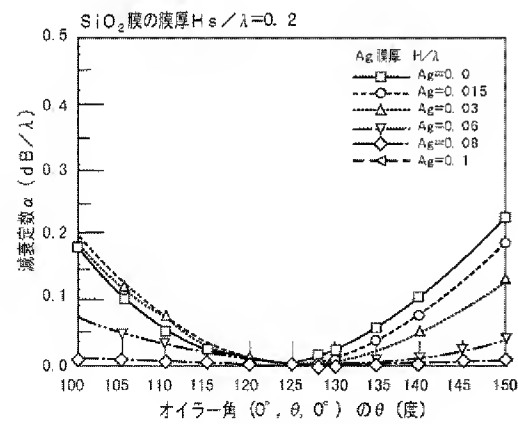
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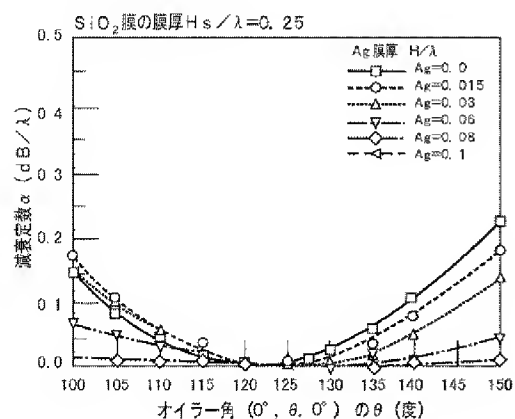
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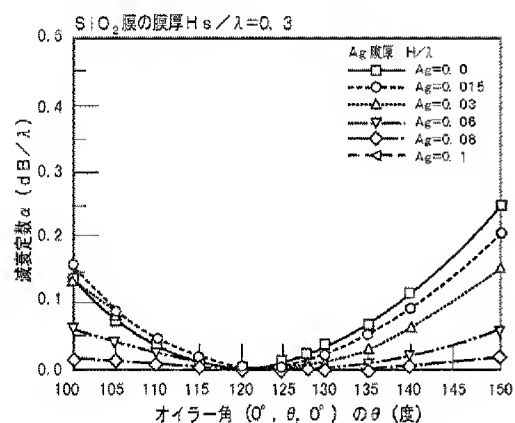
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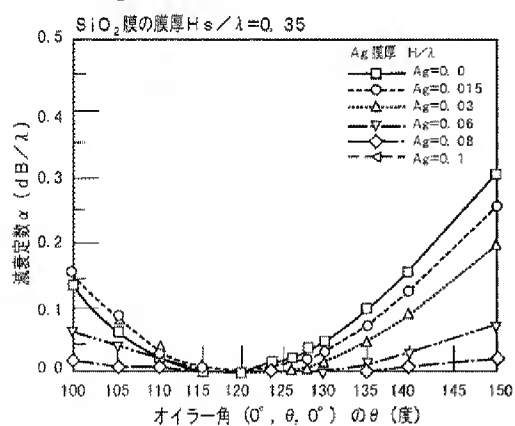
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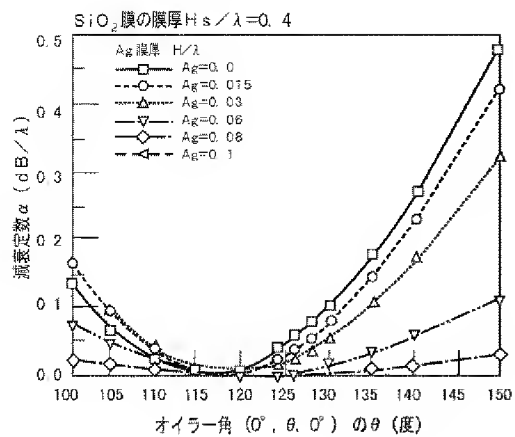
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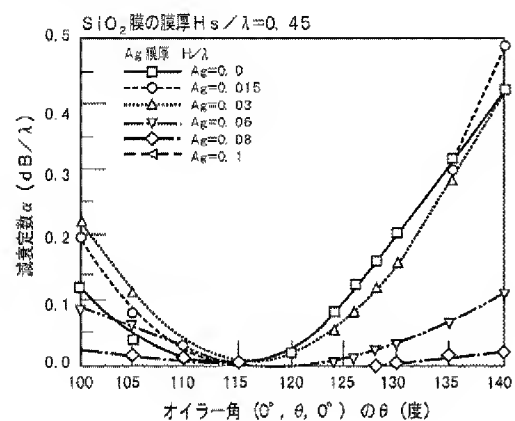
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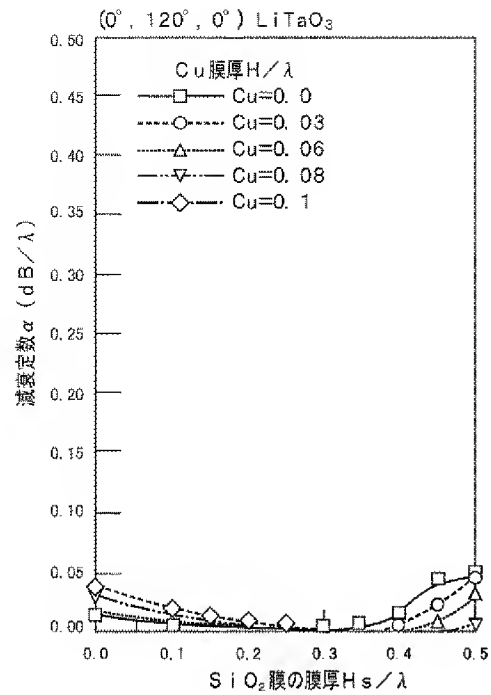
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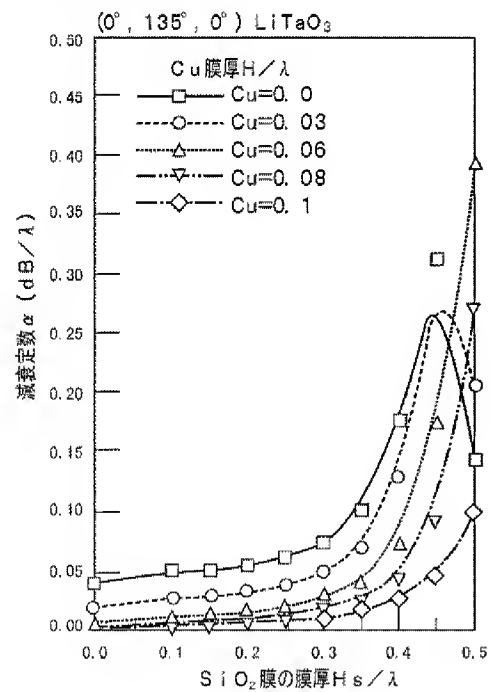
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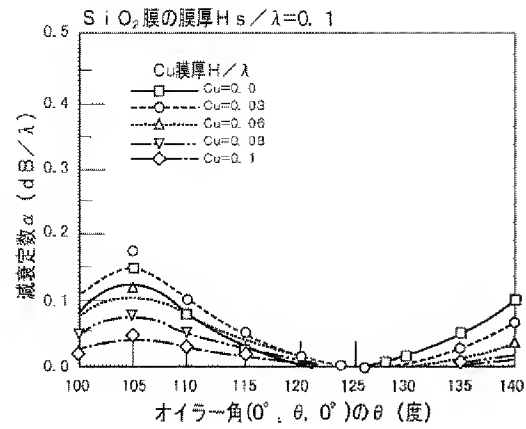
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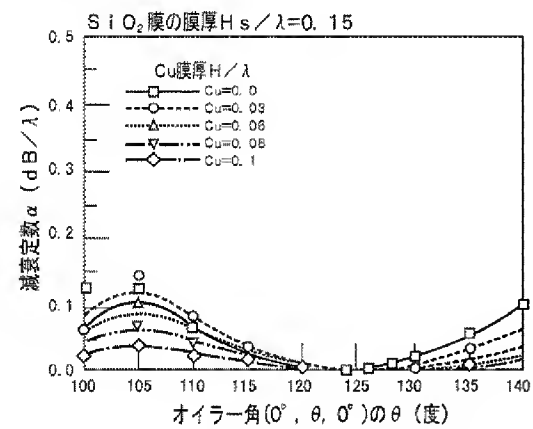
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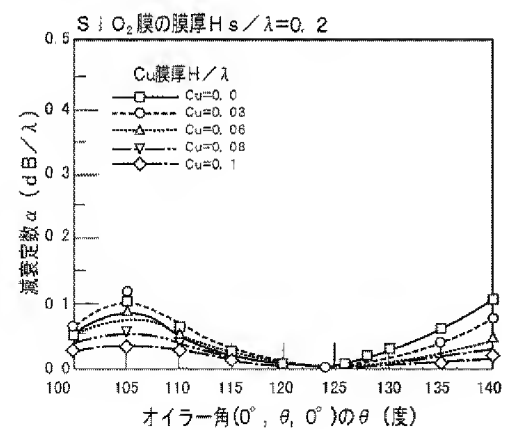
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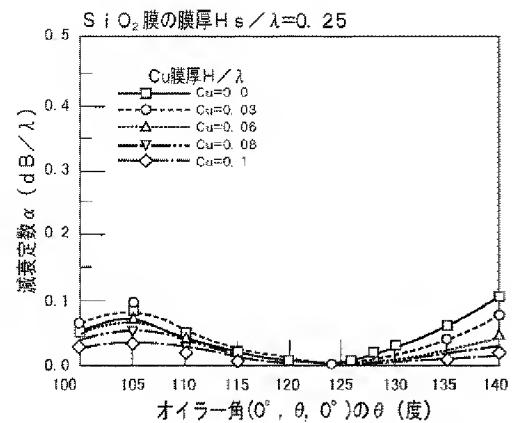
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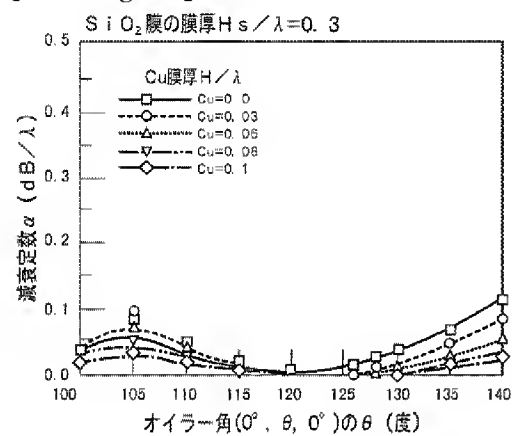
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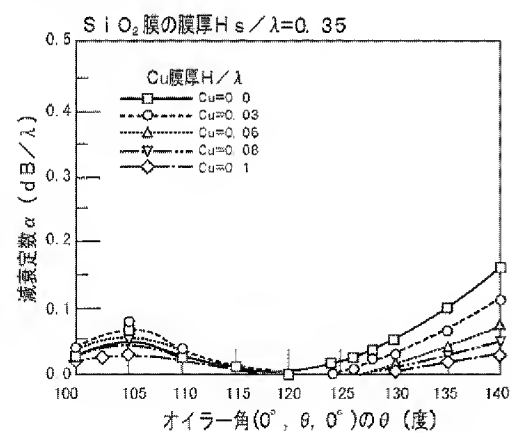
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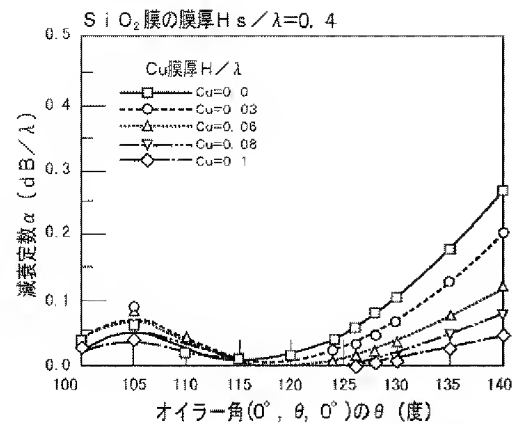
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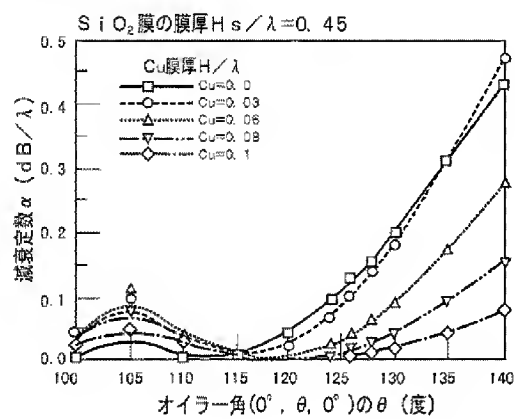
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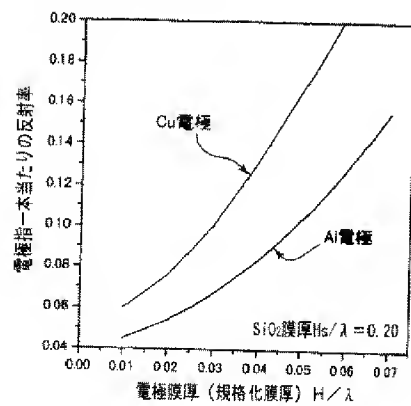
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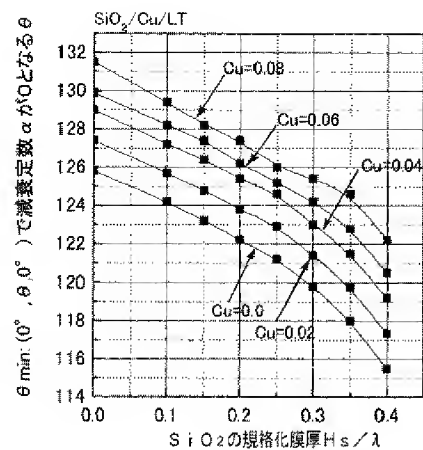
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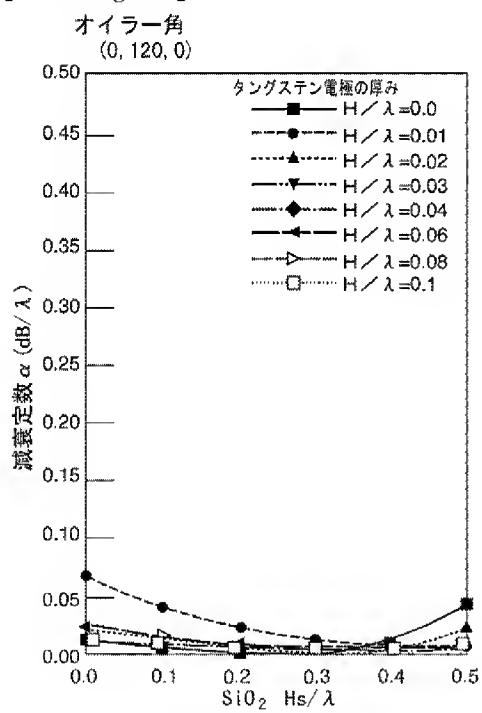
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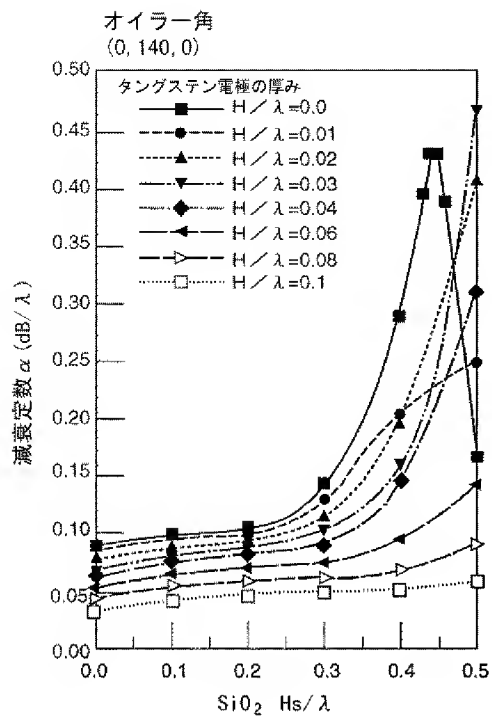
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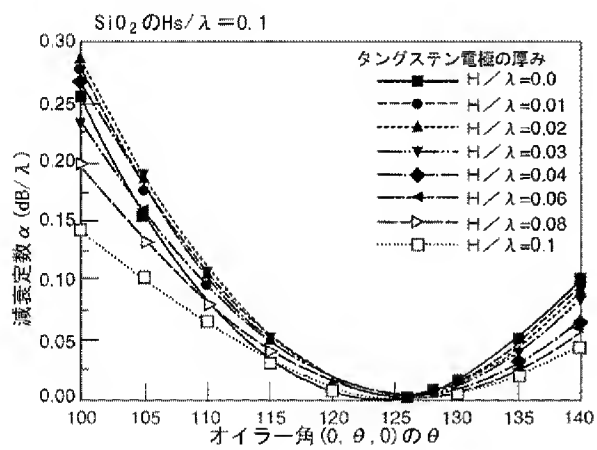
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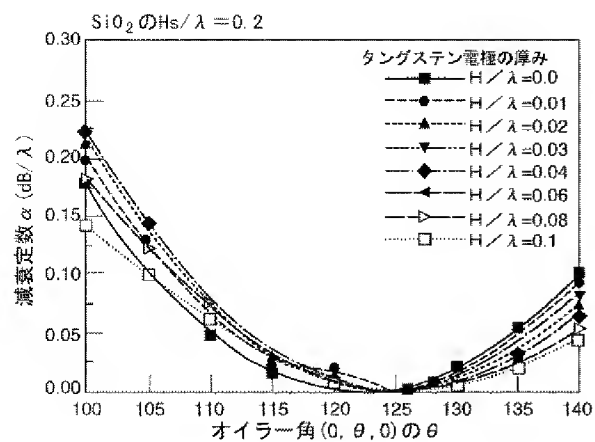
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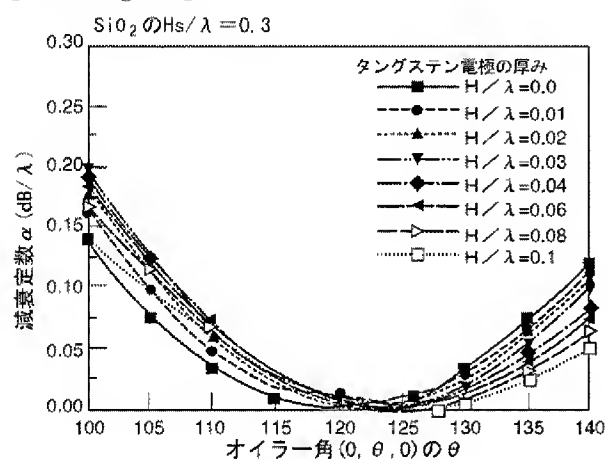
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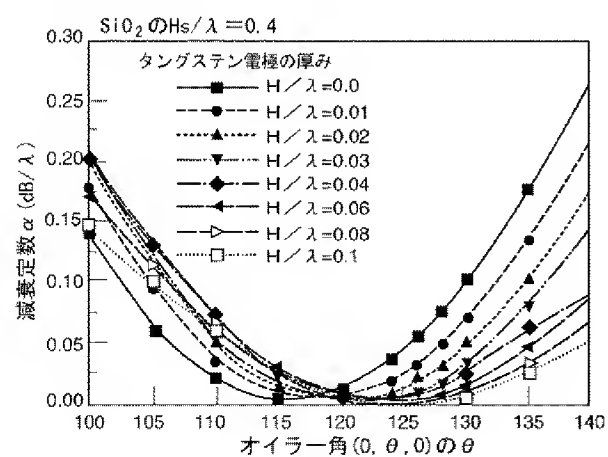
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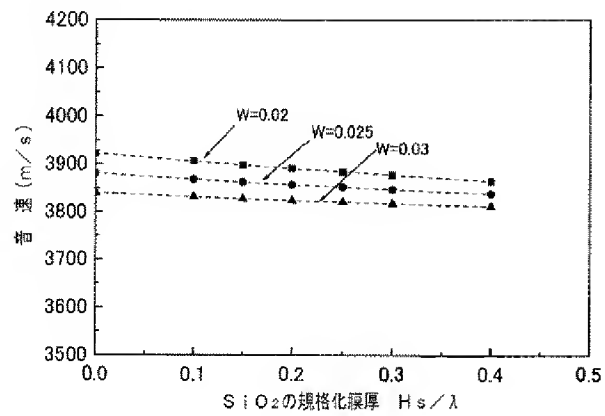
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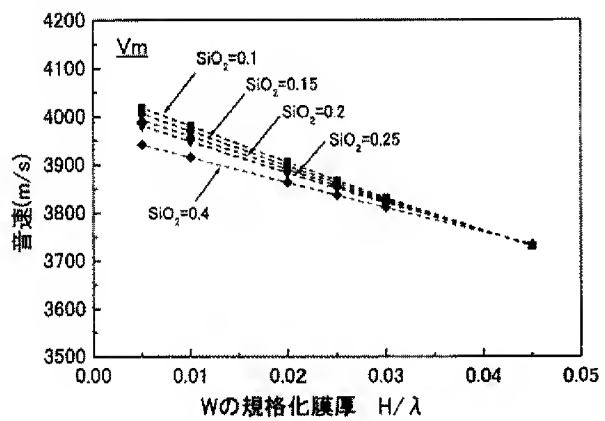
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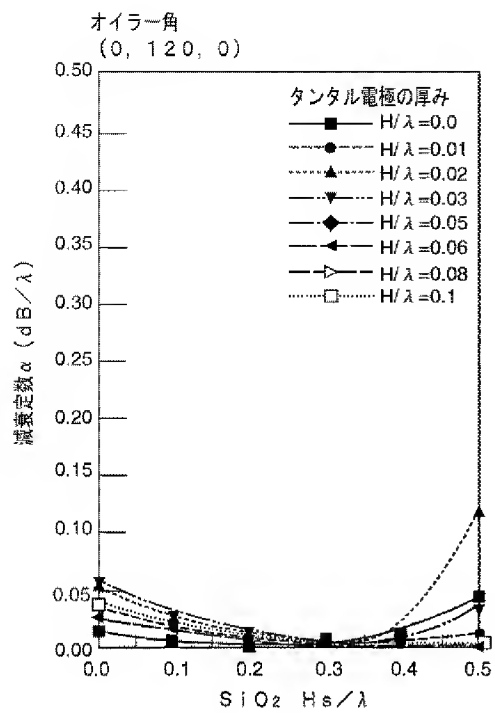
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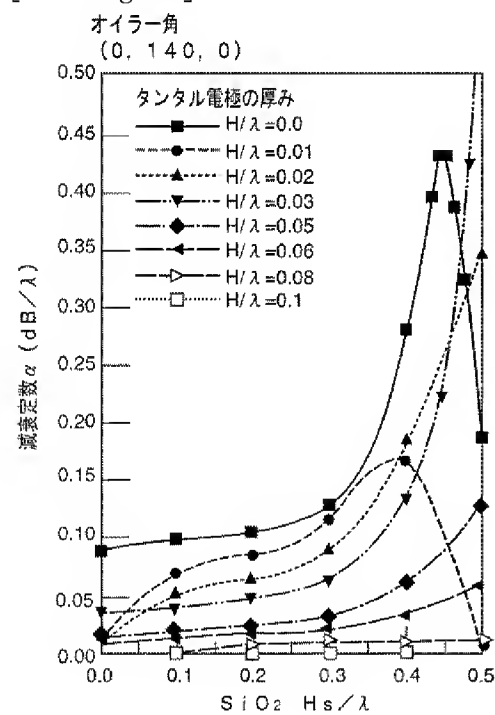
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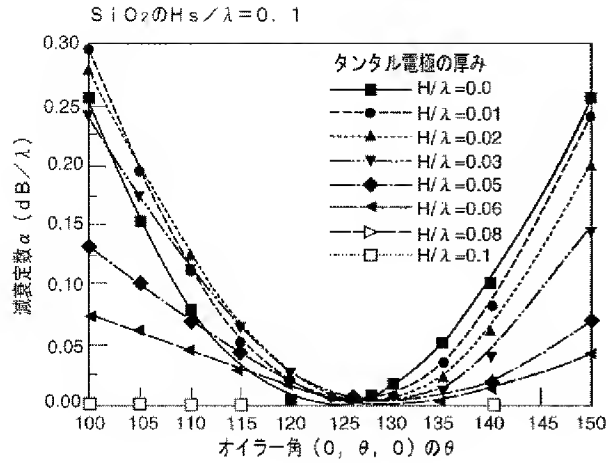
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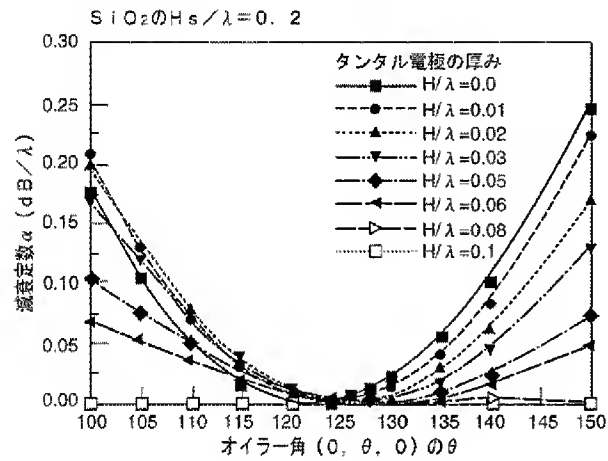
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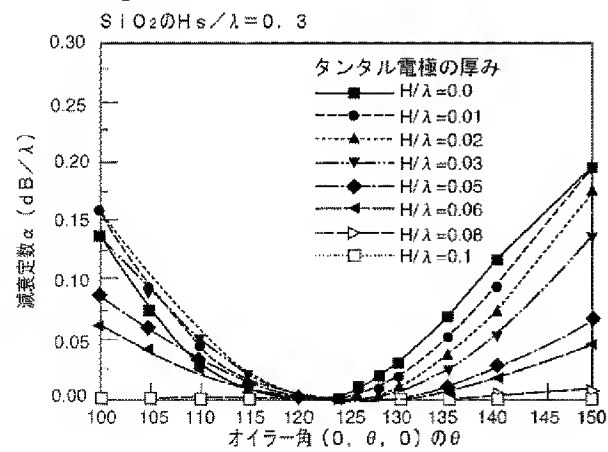
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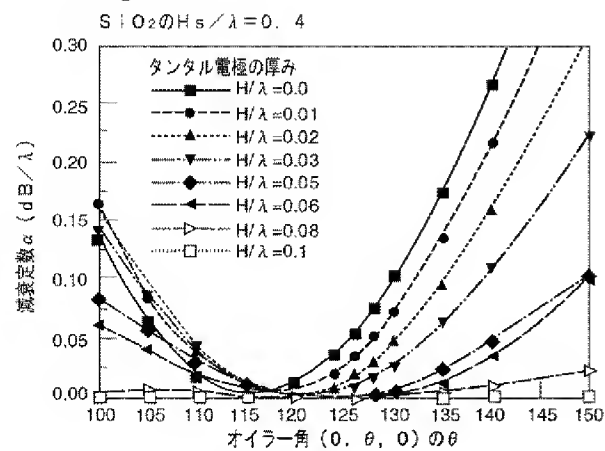
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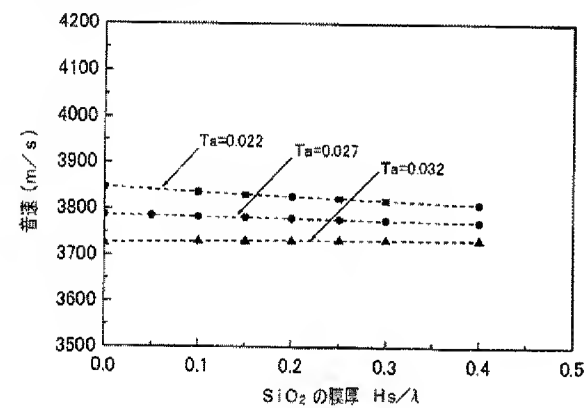
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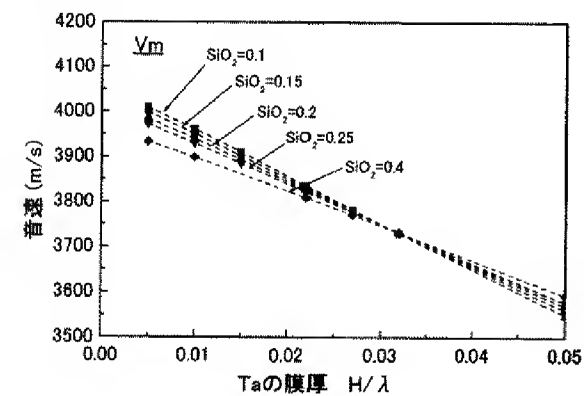
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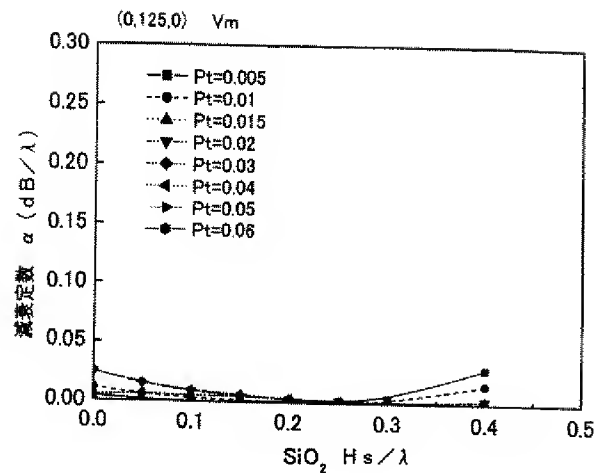
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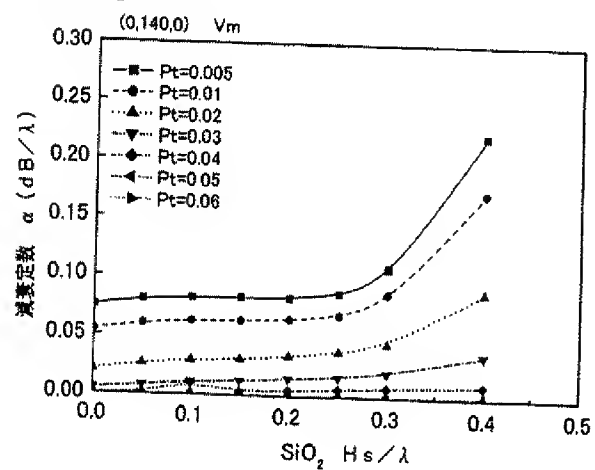
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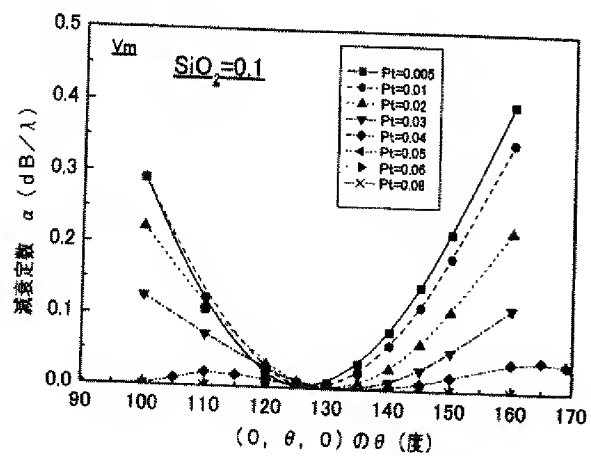
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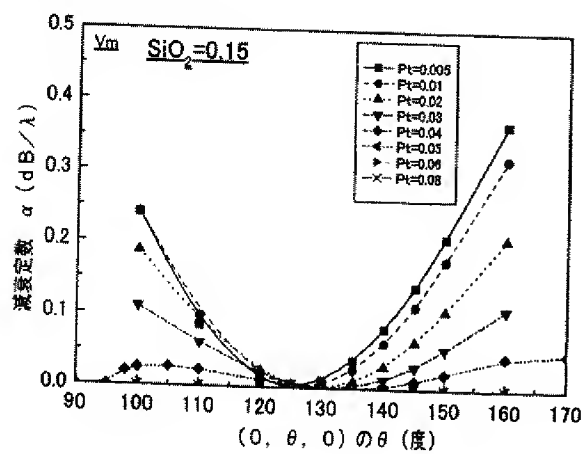
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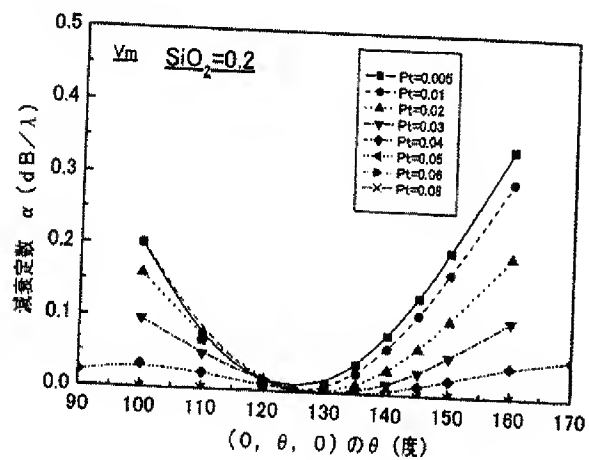
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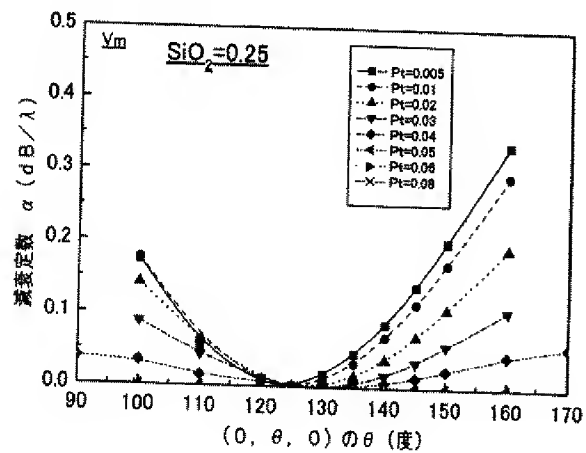
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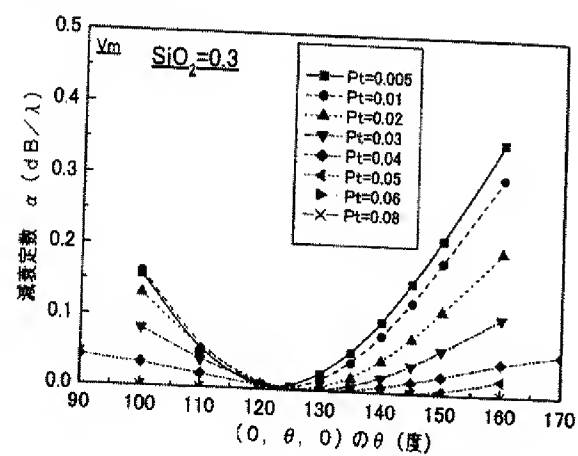
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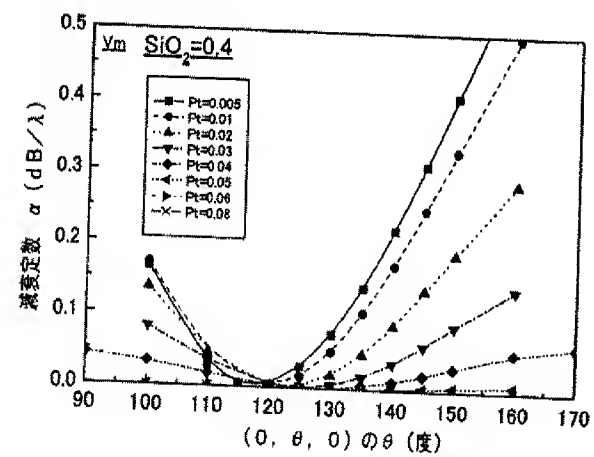
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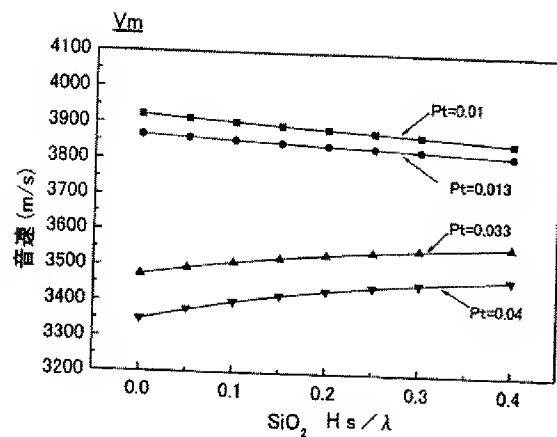
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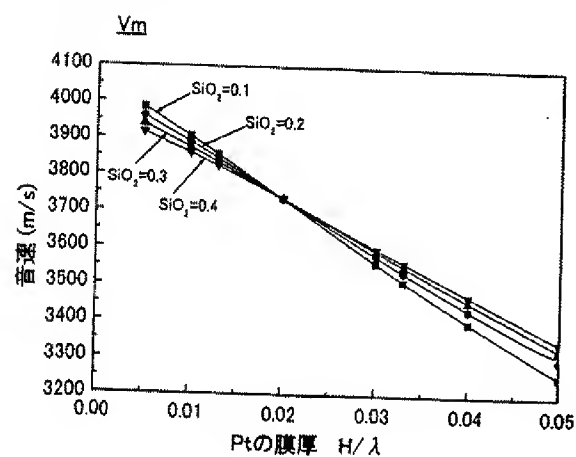
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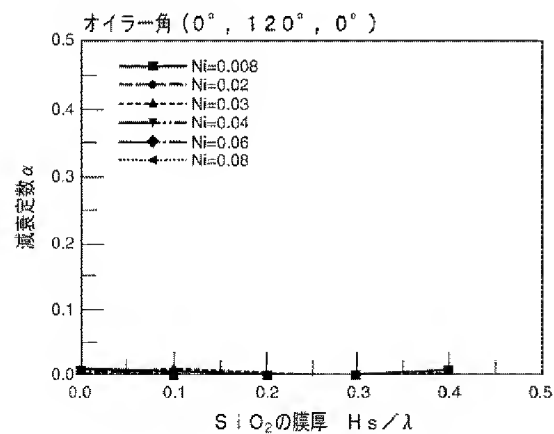
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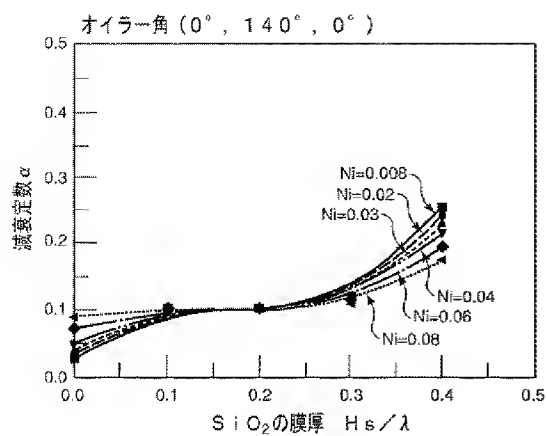
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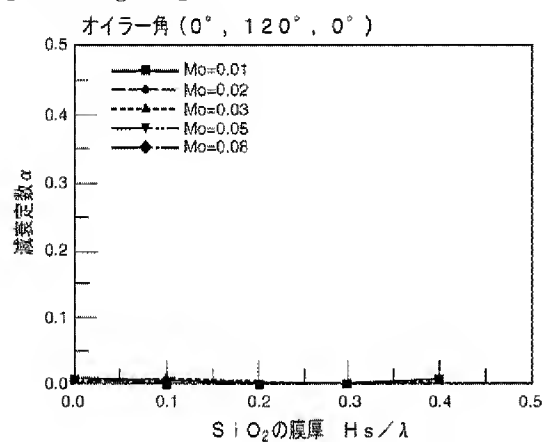
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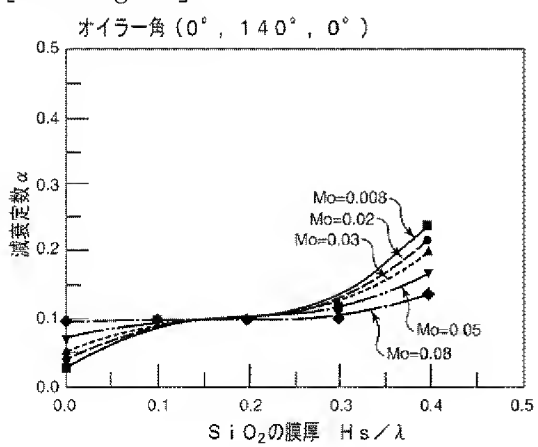
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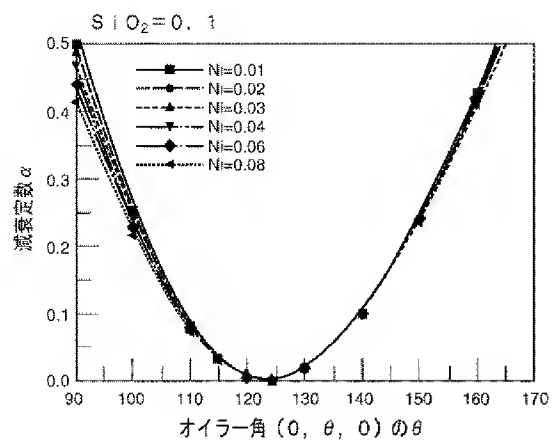
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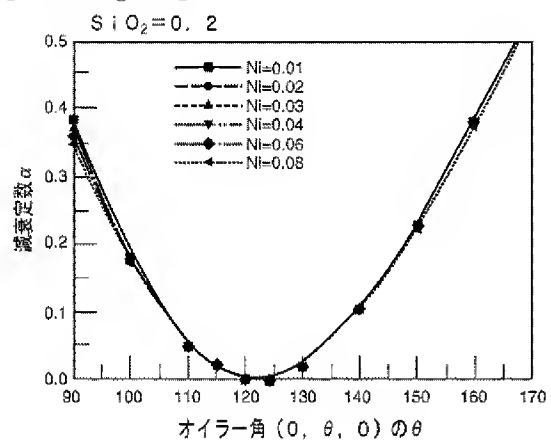
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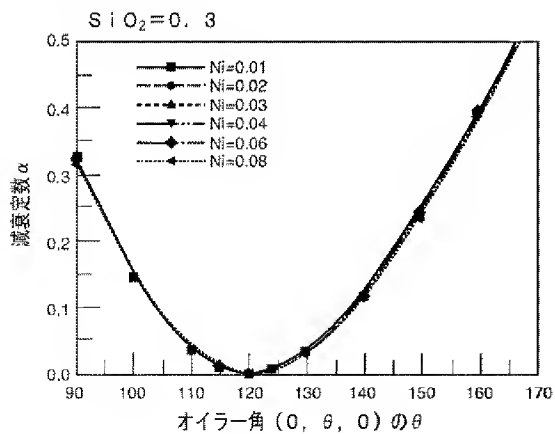
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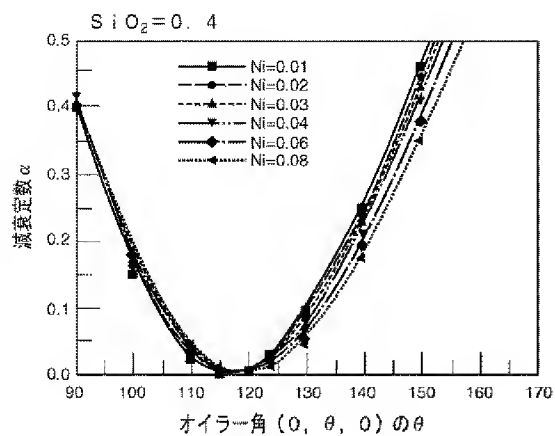
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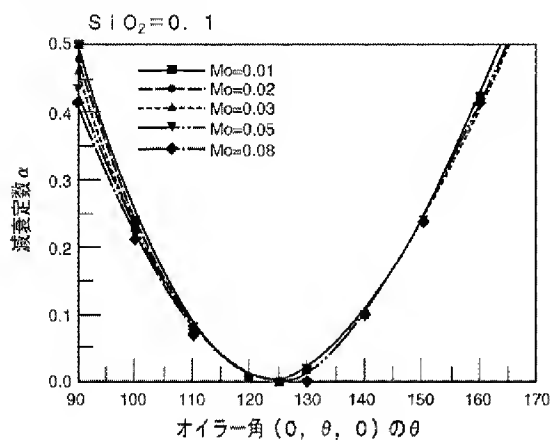
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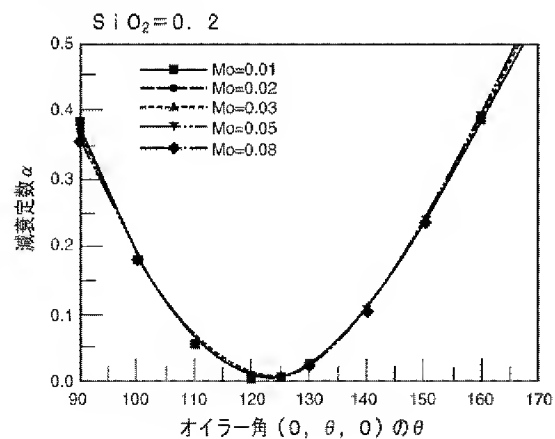
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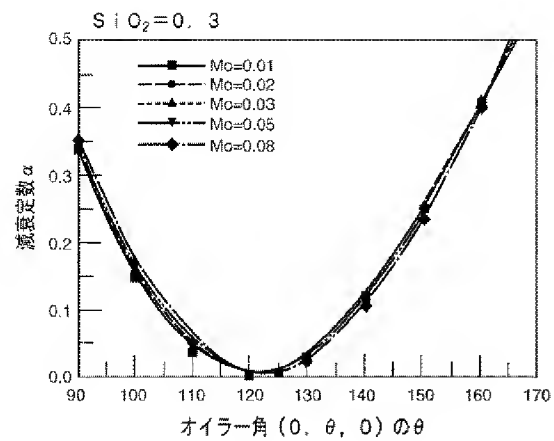
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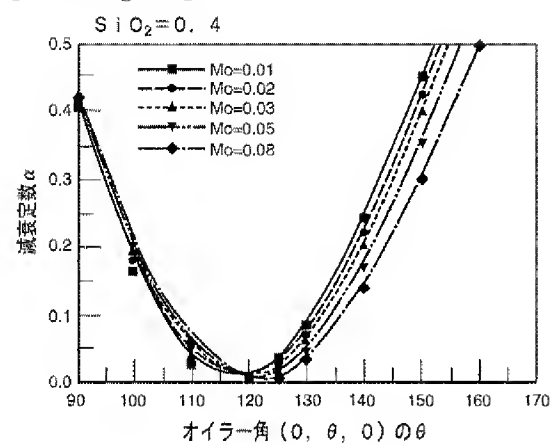
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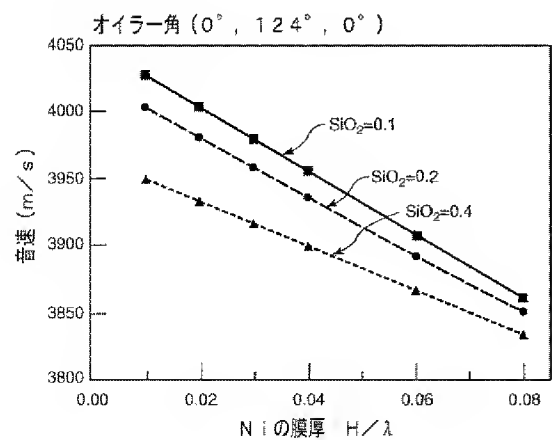
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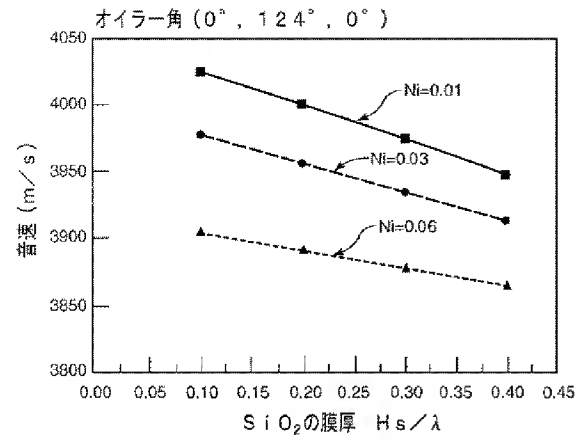
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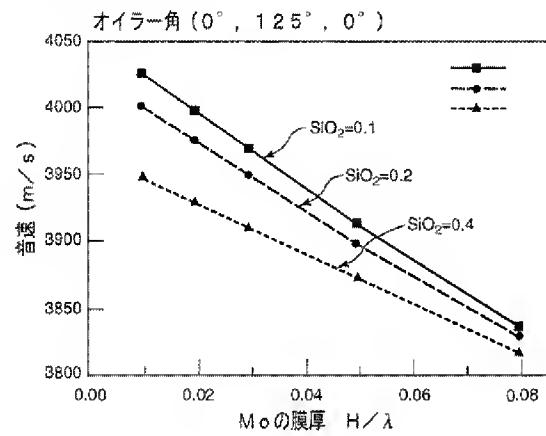
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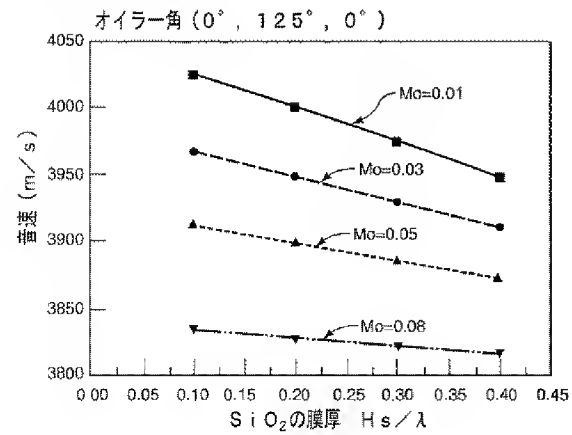
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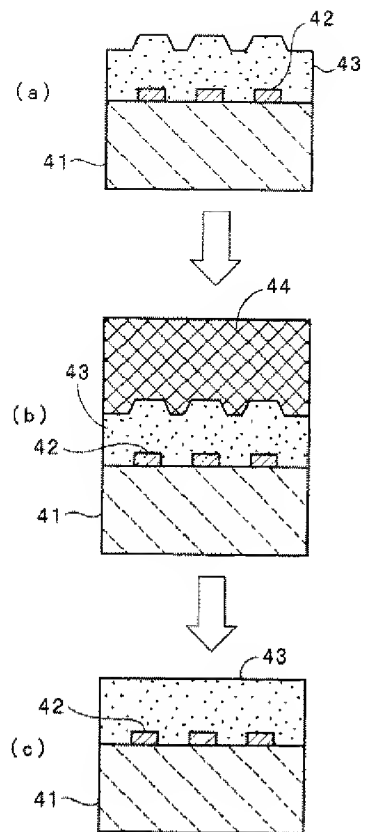
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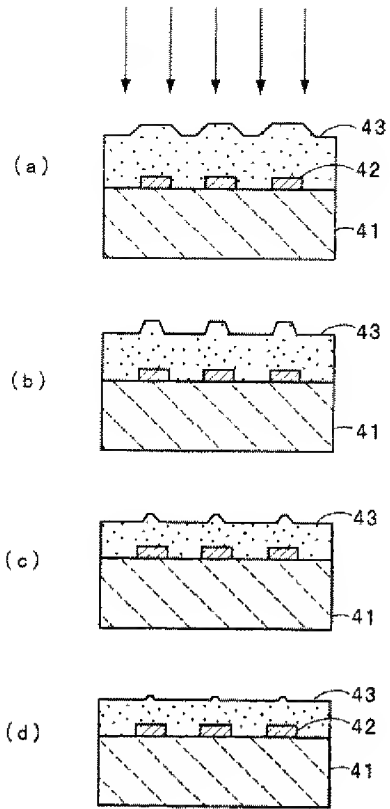
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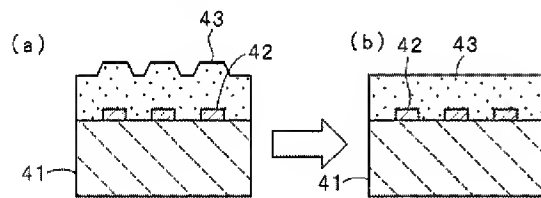
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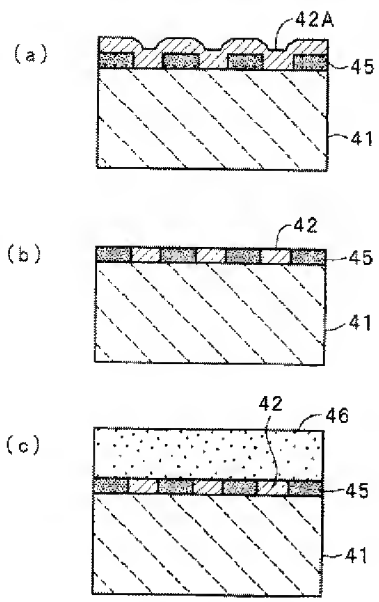
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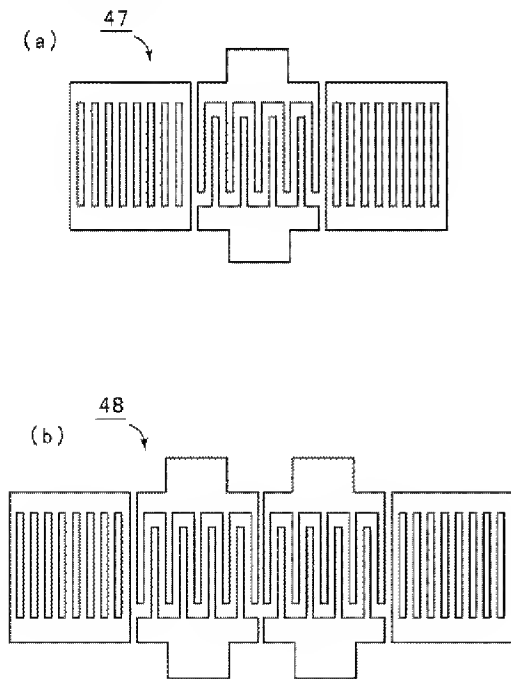
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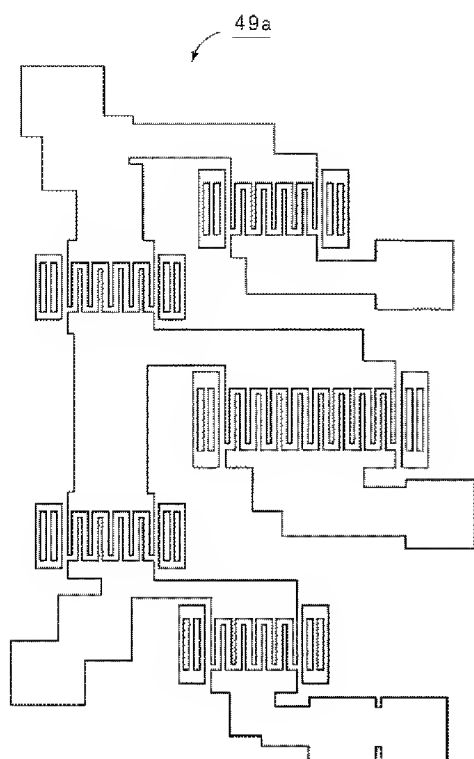
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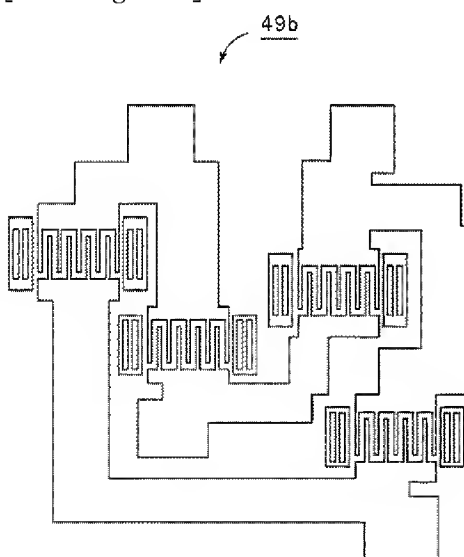
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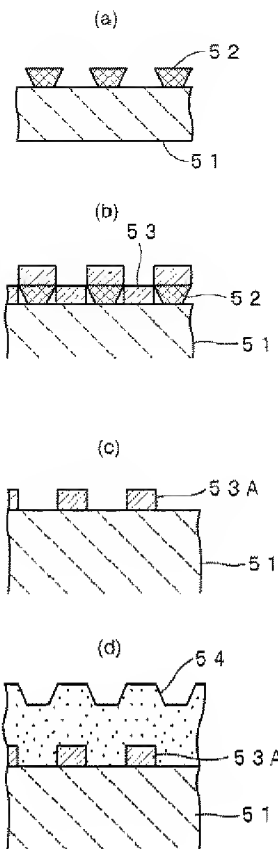
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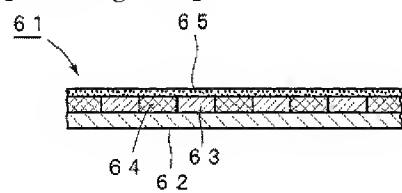
[Drawing 108]



[Drawing 109]



[Drawing 110]



[Translation done.]

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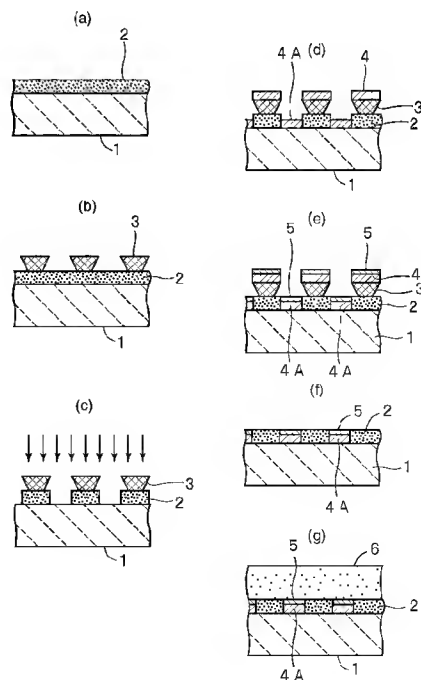
(54) 【発明の名称】 弾性表面波装置及びその製造方法

(57) 【要約】

【課題】 I D T電極を覆うように絶縁物層が形成されている構造を備えた弾性表面波装置であって、I D Tの反射係数が十分に大きく、所望でないリップルによる特性の劣化を抑制し得る弾性表面波装置の製造方法を提供する。

【解決手段】 圧電性基板としてのLiTaO₃ 基板上に、第1絶縁物層2を全面に形成し、I D T電極を形成するためのレジストパターン3を用いて、I D T電極が形成される部分の絶縁物層を除去し、第1絶縁物層が除去されている領域にAよりも大きい密度の金属または該金属を主成分とする合金からなる電極膜を形成してI D T電極4Aを形成し、第1絶縁物層上に残留しているレジストを除去し、第1絶縁物層2及びI D T電極4Aを被覆するように第2絶縁物層6を形成する、弾性表面波装置の製造方法。

【選択図】 図1



【特許請求の範囲】

【請求項 1】

電気機械結合係数が 15% 以上の LiTaO_3 または LiNbO_3 からなる圧電性基板と、
 前記圧電性基板上に形成されており、Al よりも密度の大きい金属もしくは該金属を主成分とする合金、または Al よりも密度の大きい金属もしくは該金属を主成分とする合金と他の金属とからなる積層膜からなる少なくとも 1 つの電極と、
 前記少なくとも 1 つの電極が形成されている領域を除いた残りの領域において、前記電極と略等しい膜厚に形成された第 1 絶縁物層と、
 前記電極及び第 1 絶縁物層を被覆するように形成された第 2 絶縁物層とを備え、
 前記電極の密度が、前記第 1 絶縁物層の 1.5 倍以上である、弾性表面波装置。

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【請求項 2】

圧電性基板と、
 前記圧電性基板上に形成された少なくとも 1 つの電極と、
 前記電極上に形成されており、かつ電極を構成する金属もしくは合金よりも耐腐食性に優れた金属もしくは合金からなる保護金属膜と、
 前記少なくとも 1 つの電極が形成されている領域を除いた残りの領域において、前記電極と保護金属膜との合計の膜厚と略等しい膜厚を有するように形成された第 1 絶縁物層と、
 前記保護金属膜及び第 1 絶縁物層を被覆するように形成された第 2 絶縁物層とを備える、
 弾性表面波装置。

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【請求項 3】

前記電極及び保護金属膜の積層構造の全体の平均密度が、前記第 1 絶縁物層の密度の 1.5 倍以上である、請求項 2 に記載の弾性表面波装置。

【請求項 4】

前記第 1、第 2 の絶縁物層が SiO_2 により形成されている、請求項 1～3 のいずれかに記載の弾性表面波装置。

【請求項 5】

弾性表面波の反射を利用した弾性表面波装置である、請求項 1～4 のいずれかに記載の弾性表面波装置。

【請求項 6】

前記圧電性基板が、オイラー角 ($0 \pm 3^\circ$, $104^\circ \sim 140^\circ$, $0 \pm 3^\circ$) の LiTaO_3 基板であり、前記第 1、第 2 の絶縁物層が SiO_2 より構成されており、第 1、第 2 絶縁物層を構成している SiO_2 膜の合計膜厚を HS 、弾性表面波の波長を λ としたときに、 HS/λ が $0.03 \sim 0.45$ の範囲とされており、前記電極の厚みを H 、弾性表面波の波長を λ としたときに、電極の規格化膜厚 H/λ が、下記の式 (1) を満たす値とされている、請求項 1～5 のいずれかに記載の弾性表面波装置。

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$0.005 \leq H/\lambda \leq 0.00025 \times \rho^2 - 0.01056 \times \rho + 0.16473$ (但し、 ρ は電極の平均密度) 式 (1)

【請求項 7】

前記圧電性基板が、オイラー角 ($0 \pm 3^\circ$, $115^\circ \sim 148^\circ$, $0 \pm 3^\circ$) の LiTaO_3 基板であり、前記第 1、第 2 の絶縁物層が SiO_2 膜からなり、 SiO_2 膜の合計の規格化膜厚 HS/λ が $0.03 \sim 0.45$ の範囲にあり、
 前記 Al よりも密度の大きい金属が密度 $15000 \sim 28000 \text{ kg/m}^3$ 及びヤング率 $0.5 \times 10^{11} \sim 1.0 \times 10^{11} \text{ N/m}^2$ あるいは横波音速が $1000 \sim 2000 \text{ m/s}$ である金属であり、前記電極の膜厚を H 、弾性表面波の波長を λ としたときに、規格化膜厚 H/λ が $0.013 \sim 0.032$ の範囲にある、請求項 1、4～6 のいずれかに記載の弾性表面波装置。

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【請求項 8】

前記金属が Au である、請求項 7 に記載の弾性表面波装置。

【請求項 9】

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前記 LiTaO_3 基板のオイラー角が $(0 \pm 3^\circ, 132^\circ \sim 148^\circ, 0 \pm 3^\circ)$ の範囲にある、請求項 7 または 8 に記載の弾性表面波装置。

【請求項 10】

前記 LiTaO_3 基板のオイラー角の θ が 115° 以上、 132° 未満の範囲にある、請求項 7 または 8 に記載の弾性表面波装置。

【請求項 11】

前記 LiTaO_3 基板のオイラー角 $(0 \pm 3^\circ, \theta, 0 \pm 3^\circ)$ 、前記電極の規格化膜厚 H/λ 及び第 1、第 2 絶縁物層を構成している SiO_2 の規格化膜厚 HS/λ が、下記の表 1 で示されている組み合わせのいずれかである、請求項 7 または 8 に記載の弾性表面波装置。

【表 1】

オイラー角 ($0 \pm 3^\circ, \theta, 0 \pm 3^\circ$) の θ	Au 膜厚	SiO_2 膜厚
$120.0^\circ \leq \theta < 123.0^\circ$	0.013~0.018	0.15~0.45
$123.0^\circ \leq \theta < 124.5^\circ$	0.013~0.022	0.10~0.40
$124.5^\circ \leq \theta < 125.5^\circ$	0.013~0.025	0.07~0.40
$125.5^\circ \leq \theta < 127.5^\circ$	0.013~0.025	0.06~0.40
$127.5^\circ \leq \theta < 129.0^\circ$	0.013~0.028	0.04~0.40
$129.0^\circ \leq \theta < 130.0^\circ$	0.017~0.030	0.03~0.42
$130.0^\circ \leq \theta < 131.5^\circ$	0.017~0.030	0.03~0.42
$131.5^\circ \leq \theta < 133.0^\circ$	0.018~0.028	0.05~0.33
$133.0^\circ \leq \theta < 135.0^\circ$	0.018~0.030	0.05~0.30
$135.0^\circ \leq \theta \leq 137.0^\circ$	0.019~0.032	0.05~0.25
$137.0^\circ \leq \theta \leq 140.0^\circ$	0.019~0.032	0.05~0.25

【請求項 12】

前記 LiTaO_3 基板のオイラー角 $(0 \pm 3^\circ, \theta, 0 \pm 3^\circ)$ 、前記電極の規格化膜厚 H/λ 及び第 1、第 2 絶縁物層を構成している SiO_2 の規格化膜厚 HS/λ が、下記の表 2 に示されている組み合わせのいずれかである、請求項 7 または 8 に記載の弾性表面波装置。

【表 2】

オイラー角 ($0 \pm 3^\circ, \theta, 0 \pm 3^\circ$) の θ	Au 膜厚	SiO_2 膜厚
$129.0^\circ \leq \theta < 130.0^\circ$	0.022~0.028	0.04~0.40
$130.0^\circ \leq \theta < 131.5^\circ$	0.022~0.028	0.04~0.40
$131.5^\circ \leq \theta < 133.0^\circ$	0.022~0.028	0.05~0.33
$133.0^\circ \leq \theta < 135.0^\circ$	0.022~0.030	0.05~0.30
$135.0^\circ \leq \theta < 137.0^\circ$	0.022~0.032	0.05~0.25
$137.0^\circ \leq \theta \leq 140.0^\circ$	0.022~0.032	0.05~0.25

【請求項 13】

前記圧電性基板が、オイラー角 $(0 \pm 3^\circ, 113^\circ \sim 142^\circ, 0 \pm 3^\circ)$ の LiTaO_3 基板であり、前記第 1、第 2 絶縁物層が SiO_2 膜からなり、 SiO_2 膜の合計の規

規格化膜厚 HS/λ が $0.10 \sim 0.40$ の範囲にあり、

前記 A 1 よりも密度の大きい金属が密度 $5000 \sim 15000 \text{ kg/m}^3$ 及びヤング率 $0.5 \times 10^{11} \sim 1.0 \times 10^{11} \text{ N/m}^2$ あるいは横波音速が $1000 \sim 2000 \text{ m/s}$ である金属であり、前記電極の膜厚を H 、弾性表面波の波長を λ としたときに、規格化膜厚 H/λ が $0.01 \sim 0.08$ の範囲にある、請求項 1、4～6 のいずれかに記載の弾性表面波装置。

【請求項 14】

前記金属が A 9 である、請求項 13 に記載の弾性表面波装置。

【請求項 15】

前記電極の規格化膜厚 H/λ が $0.01 \sim 0.08$ であり、前記 SiO_2 膜の合計の規格化膜厚 HS/λ と、 LiTaO_3 基板のオイラー角が下記の表 3 に示す組み合わせのいずれかである、請求項 13 または 14 に記載の弾性表面波装置。

【表 3】

Ag 膜厚 H/λ : $0.01 \sim 0.08$ のとき

SiO_2 膜厚	LiTaO_3 のオイラー角
$0.15 \sim 0.18$	$0 \pm 3, 117 \sim 137, 0 \pm 3$
$0.18 \sim 0.23$	$0 \pm 3, 117 \sim 136, 0 \pm 3$
$0.23 \sim 0.28$	$0 \pm 3, 115 \sim 135, 0 \pm 3$
$0.28 \sim 0.33$	$0 \pm 3, 113 \sim 133, 0 \pm 3$
$0.33 \sim 0.38$	$0 \pm 3, 113 \sim 135, 0 \pm 3$
$0.38 \sim 0.40$	$0 \pm 3, 113 \sim 132, 0 \pm 3$

【請求項 16】

前記電極の規格化膜厚 H/λ が $0.02 \sim 0.06$ であり、前記 SiO_2 膜の合計の規格化膜厚 HS/λ と、 LiTaO_3 基板のオイラー角が下記の表 4 に示す組み合わせのいずれかである、請求項 13 または 14 に記載の弾性表面波装置。

【表 4】

Ag 膜厚 H/λ : $0.02 \sim 0.06$ のとき

SiO_2 膜厚	LiTaO_3 のオイラー角
$0.15 \sim 0.18$	$0 \pm 3, 120 \sim 133, 0 \pm 3$
$0.18 \sim 0.23$	$0 \pm 3, 120 \sim 137, 0 \pm 3$
$0.23 \sim 0.28$	$0 \pm 3, 120 \sim 135, 0 \pm 3$
$0.28 \sim 0.33$	$0 \pm 3, 118 \sim 135, 0 \pm 3$
$0.33 \sim 0.38$	$0 \pm 3, 115 \sim 133, 0 \pm 3$
$0.38 \sim 0.40$	$0 \pm 3, 113 \sim 130, 0 \pm 3$

【請求項 17】

前記電極の規格化膜厚 H/λ が $0.03 \sim 0.05$ であり、前記 SiO_2 膜の合計の規格化膜厚 HS/λ と、 LiTaO_3 基板のオイラー角が下記の表 5 に示す組み合わせのいずれかである、請求項 13 または 14 に記載の弾性表面波装置。

【表 5】

A g 膜厚 H/λ : 0.03 ~ 0.05 のとき

SiO ₂ 膜厚	LiTaO ₃ のオイラー角
0.15~0.18	$0 \pm 3, 122 \sim 142, 0 \pm 3$
0.18~0.23	$0 \pm 3, 120 \sim 140, 0 \pm 3$
0.23~0.28	$0 \pm 3, 117 \sim 138, 0 \pm 3$
0.28~0.33	$0 \pm 3, 116 \sim 136, 0 \pm 3$
0.33~0.38	$0 \pm 3, 114 \sim 135, 0 \pm 3$
0.38~0.40	$0 \pm 3, 113 \sim 130, 0 \pm 3$

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【請求項 18】

前記圧電性基板が、オイラー角 ($0 \pm 3^\circ, 113^\circ \sim 137^\circ, 0 \pm 3^\circ$) の LiTaO₃ 基板であり、前記第 1. 第 2 絶縁物層が SiO₂ 膜からなり、SiO₂ 膜の合計の規格化膜厚 HS/λ が 0.10 ~ 0.40 の範囲にあり、

前記 A 1 よりも密度の大きい金属が密度 $5000 \sim 15000 \text{ kg/m}^3$ 及びヤング率 $1.0 \times 10^{11} \sim 2.05 \times 10^{11} \text{ N/m}^2$ あるいは横波音速が $2000 \sim 2800 \text{ m/s}$ である金属であり、前記電極の膜厚を H 、弾性表面波の波長を λ としたときに、規格化膜厚 H/λ が 0.01 ~ 0.08 の範囲にある、請求項 1. 4 ~ 6 のいずれかに記載の弾性表面波装置。

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【請求項 19】

前記金属が Cu である、請求項 18 に記載の弾性表面波装置。

【請求項 20】

前記 LiTaO₃ 基板のオイラー角及び前記 SiO₂ の合計の規格化膜厚 HS/λ が、下記の表 6 に示されている組み合わせのいずれかである、請求項 18 または 19 に記載の弾性表面波装置。

【表 6】

SiO ₂ 膜厚	LiTaO ₃ のオイラー角
0.15~0.18	$(0 \pm 3, 117 \sim 137, 0 \pm 3)$
0.18~0.23	$(0 \pm 3, 117 \sim 136, 0 \pm 3)$
0.23~0.28	$(0 \pm 3, 115 \sim 135, 0 \pm 3)$
0.28~0.33	$(0 \pm 3, 113 \sim 133, 0 \pm 3)$
0.33~0.38	$(0 \pm 3, 113 \sim 135, 0 \pm 3)$
0.38~0.4	$(0 \pm 3, 113 \sim 132, 0 \pm 3)$

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【請求項 21】

前記オイラー角 ($0 \pm 3^\circ, \theta, 0 \pm 3^\circ$) の θ が下記の式 (2) の範囲にあることを特徴とする、請求項 18 または 19 に記載の弾性表面波装置。

$$\theta_{\min} - 2^\circ < \theta \leq \theta_{\min} + 2^\circ \quad \text{式 (2)}$$

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但し、式 (2) 中、 θ_{\min} は、IDT の規格化膜厚 H/λ が下記の (a) ~ (e) の範囲の場合、それぞれ下記の式 A ~ E で表される値である。

(a) $0 < H/\lambda \leq 0.01$ のとき

$$\theta_{\min} = -139.713 \times HS^3 + 43.07132 \times HS^2 - 20.568011 \times HS + 125.8314 \quad \text{式 A}$$

(b) $0.01 < H/\lambda \leq 0.03$ のとき

$$\theta_{\min} = -139.660 \times HS^3 + 46.02985 \times HS^2 - 21.141500 \times HS + 127.4181 \quad \text{式 B}$$

(c) $0.03 < H/\lambda \leq 0.05$ のとき

$$\theta_{\min} = -139.607 \times HS^3 + 48.98838 \times HS^2 - 21.714900 \times HS + 129.0048 \quad \text{式 C}$$

(d) $0.05 < H/\lambda \leq 0.07$ のとき

$$\theta_{\min} = -112.068 \times HS^3 + 39.60355 \times HS^2 - 21.186000$$

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$\times HS + 129.9397$ 式D(e) $0.07 < H/\lambda \leq 0.09$ のとき
 $\theta_{\min} = -126.954 \times HS^3 + 67.40488 \times HS^2$
 $-29.482000 \times HS + 131.5686$ 式E

【請求項22】

前記 SiO_2 膜の合計の規格化膜厚 HS/λ と、 LiTaO_3 基板のオイラー角が下記の表7に示す組み合わせのいずれかである、請求項18または19に記載の弾性表面波装置

【表7】

SiO_2 膜厚	LiTaO_3 のオイラー角
0.15~0.18	(0 ± 3 , $117 \sim 125$, 0 ± 3)
0.18~0.23	(0 ± 3 , $117 \sim 125$, 0 ± 3)
0.23~0.28	(0 ± 3 , $115 \sim 125$, 0 ± 3)
0.28~0.33	(0 ± 3 , $113 \sim 125$, 0 ± 3)
0.33~0.38	(0 ± 3 , $113 \sim 125$, 0 ± 3)
0.38~0.40	(0 ± 3 , $113 \sim 125$, 0 ± 3)

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【請求項23】

前記圧電性基板が、オイラー角 ($0 \pm 3^\circ$, $112^\circ \sim 138^\circ$, $0 \pm 3^\circ$) の LiTaO_3 基板であり、前記第1. 第2絶縁物層が SiO_2 膜からなり、 SiO_2 膜の合計の規格化膜厚 HS/λ が $0.10 \sim 0.40$ の範囲にあり、

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前記Aよりも密度の大きい金属が密度 $15000 \sim 23000 \text{ kg/m}^3$ 及びヤング率 $2.0 \times 10^{11} \sim 4.5 \times 10^{11} \text{ N/m}^2$ あるいは横波音速が $2800 \sim 3500 \text{ m/s}$ である金属であり、前記電極の膜厚を H 、弾性表面波の波長を λ としたときに、規格化膜厚 H/λ が $0.025 \sim 0.06$ の範囲にある、請求項1. 4~6のいずれかに記載の弾性表面波装置。

【請求項24】

前記金属がタングステンである、請求項23に記載の弾性表面波装置。

【請求項25】

前記IDTの規格化膜厚 H/λ が、 $0.012 \sim 0.058$ の範囲にある、請求項23または24に記載の弾性表面波装置。

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【請求項26】

前記IDTの規格化膜厚 H/λ が、 $0.015 \sim 0.042$ の範囲にある、請求項25に記載の弾性表面波装置。

【請求項27】

前記 LiTaO_3 基板が、オイラー角 ($0 \pm 3^\circ$, $115^\circ \sim 135^\circ$, $0 \pm 3^\circ$) の LiTaO_3 基板である、請求項23~25のいずれかに記載の弾性表面波装置。

【請求項28】

前記電極の規格化膜厚 H/λ が、 $0.012 \sim 0.058$ であり、前記 SiO_2 膜の合計の規格化膜厚 HS/λ と、 LiTaO_3 基板のオイラー角が下記の表8に示す組み合わせのいずれかである、請求項23または24に記載の弾性表面波装置。

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【表 8】

電極の $H/\lambda = 0.012 \sim 0.053$ のとき

SiO ₂ の規格化膜厚	LiTaO ₃ のオイラー角
0.1~0.15	(0±3, 114.2~138, 0±3)
0.15~0.2	(0±3, 113~137.8, 0±3)
0.2~0.3	(0±3, 113~137.5, 0±3)
0.3~0.35	(0±3, 112.7~137, 0±3)
0.35~0.4	(0±3, 112.5~136, 0±3)

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【請求項 29】

前記電極の規格化膜厚 H/λ が、0.015~0.042 であり、前記 SiO₂ 膜の合計の規格化膜厚 HS/λ と、LiTaO₃ 基板のオイラー角が下記の表 9 に示す組み合わせのいずれかである、請求項 28 または 24 に記載の弾性表面波装置。

【表 9】

電極の $H/\lambda = 0.015 \sim 0.042$ のとき

SiO ₂ の規格化膜厚	LiTaO ₃ のオイラー角
0.1~0.15	(0±3, 114.3~138, 0±3)
0.15~0.2	(0±3, 113~137.5, 0±3)
0.2~0.3	(0±3, 112.5~137, 0±3)
0.3~0.35	(0±3, 112.2~136.5, 0±3)
0.35~0.4	(0±3, 112~135.3, 0±3)

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【請求項 30】

前記圧電性基板が、オイラー角 (0±3°, 104°~148°, 0±3°) の LiTaO₃ 基板であり、前記第 1. 第 2 絶縁物層が SiO₂ 膜からなり、SiO₂ 膜の合計の規格化膜厚 HS/λ が 0.10~0.40 の範囲にあり、

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前記 A よりも密度の大きい金属が密度 15000~23000 kg/m³ 及びヤング率 $1.0 \times 10^{11} \sim 2.0 \times 10^{11}$ N/m² あるいは横波音速が 2000~2800 m/s である金属であり、前記電極の膜厚を H、弾性表面波の波長を λ としたときに、規格化膜厚 H/λ が 0.004~0.055 の範囲にある、請求項 1. 4~6 のいずれかに記載の弾性表面波装置。

【請求項 31】

前記金属がタンタルである、請求項 30 に記載の弾性表面波装置。

【請求項 32】

前記電極の規格化膜厚 H/λ が、0.01~0.55 の範囲にある、請求項 30 または 31 に記載の弾性表面波装置。

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【請求項 33】

前記電極の規格化膜厚 H/λ が、0.016~0.045 の範囲にある、請求項 30 または 31 に記載の弾性表面波装置。

【請求項 34】

前記圧電性基板が、オイラー角 (0±3°, 111°~143°, 0±3°) の LiTaO₃ 基板である、請求項 30~32 のいずれかに記載の弾性表面波装置。

【請求項 35】

前記電極の規格化膜厚 H/λ が、0.01~0.055 であり、前記 SiO₂ 膜の合計の規格化膜厚 HS/λ と、LiTaO₃ 基板のオイラー角が下記の表 10 に示す組み合わせのいずれかである、請求項 30 または 31 に記載の弾性表面波装置。

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【表 1 0】

電極の $H/\lambda = 0.01 \sim 0.055$ のとき

SiO ₂ の規格化膜厚	LiTaO ₃ のオイラー角
0.1~0.15	(0±3, 110.5~148, 0±3)
0.15~0.2	(0±3, 108~147.5, 0±3)
0.2~0.3	(0±3, 105~148, 0±3)
0.3~0.35	(0±3, 104.5~148, 0±3)
0.35~0.4	(0±3, 104~145, 0±3)

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【請求項 3 6】

前記電極の規格化膜厚 H/λ が 0.016~0.045 であり、前記 SiO₂ 膜の合計の規格化膜厚 HS/λ と、LiTaO₃ 基板のオイラー角が下記の表 1 1 に示す組み合わせのいずれかである、請求項 3 0 または 3 1 に記載の弾性表面波装置。

【表 1 1】

電極の $H/\lambda = 0.016 \sim 0.045$ のとき

SiO ₂ の規格化膜厚	LiTaO ₃ のオイラー角
0.1~0.15	(0±3, 113~144, 0±3)
0.15~0.2	(0±3, 111~144, 0±3)
0.2~0.3	(0±3, 108~144, 0±3)
0.3~0.35	(0±3, 107.5~143, 0±3)
0.35~0.4	(0±3, 107~140.5, 0±3)

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【請求項 3 7】

前記圧電性基板が、オイラー角 (0±3°, 90°~169°, 0±3°) の LiTaO₃ 基板であり、前記第 1. 第 2 絶縁物層が SiO₂ 膜からなり、SiO₂ 膜の合計の規格化膜厚 HS/λ が 0.10~0.40 の範囲にあり、

前記 A 1 よりも密度の大きい金属が密度 15000~23000 kg/m³ 及びヤング率 $1.0 \times 10^{11} \sim 2.0 \times 10^{11}$ N/m² あるいは横波音速が 1000~2000 m/s の金属であり、前記電極の膜厚を H 、弾性表面波の波長を λ としたときに、規格化膜厚 H/λ が 0.005~0.054 の範囲にある、請求項 1. 4~6 のいずれかに記載の弾性表面波装置。

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【請求項 3 8】

前記金属が白金である、請求項 3 7 に記載の弾性表面波装置。

【請求項 3 9】

前記圧電性基板のオイラー角が (0±3°, 90°~155°, 0±3°) であり、前記電極の規格化膜厚 H/λ が 0.01~0.04 の範囲にある、請求項 3 7 または 3 8 に記載の弾性表面波装置。

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【請求項 4 0】

前記 LiTaO₃ 基板のオイラー角及び前記 SiO₂ の合計の規格化膜厚 HS/λ が、下記の表 1 2 に示されている組み合わせのいずれかである、請求項 3 9 に記載の弾性表面波装置。

【表 1 2】

白金 $H/\lambda = 0.01 \sim 0.04$ のとき

SiO_2 厚(H_s/λ)	オイラー角
$0.1 \leq H_s/\lambda < 0.15$	$(0 \pm 3^\circ, 90^\circ \sim 169^\circ, 0 \pm 3^\circ)$
$0.15 \leq H_s/\lambda < 0.2$	$(0 \pm 3^\circ, 90^\circ \sim 167^\circ, 0 \pm 3^\circ)$
$0.20 \leq H_s/\lambda < 0.25$	$(0 \pm 3^\circ, 90^\circ \sim 167^\circ, 0 \pm 3^\circ)$
$0.25 \leq H_s/\lambda < 0.3$	$(0 \pm 3^\circ, 90^\circ \sim 164^\circ, 0 \pm 3^\circ)$
$0.3 \leq H_s/\lambda < 0.4$	$(0 \pm 3^\circ, 90^\circ \sim 163^\circ, 0 \pm 3^\circ)$

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【請求項 4 1】

前記圧電性基板のオイラー角が $(0 \pm 3^\circ, 102^\circ \sim 150^\circ, 0 \pm 3^\circ)$ であり、前記電極の規格化膜厚 H/λ が $0.013 \sim 0.033$ の範囲にある、請求項 37 または 38 に記載の弾性表面波装置。

【請求項 4 2】

前記 SiO_2 膜の合計の規格化膜厚 H_s/λ と、 LiTaO_3 基板のオイラー角が下記の表 1 3 に示す組み合わせのいずれかである、請求項 4 1 に記載の弾性表面波装置。

【表 1 3】

白金 $H/\lambda = 0.013 \sim 0.033$ のとき

SiO_2 厚(H_s/λ)	オイラー角
$0.1 \leq H_s/\lambda < 0.15$	$(0 \pm 3^\circ, 106^\circ \sim 155^\circ, 0 \pm 3^\circ)$
$0.15 \leq H_s/\lambda < 0.2$	$(0 \pm 3^\circ, 104^\circ \sim 155^\circ, 0 \pm 3^\circ)$
$0.20 \leq H_s/\lambda < 0.25$	$(0 \pm 3^\circ, 102^\circ \sim 155^\circ, 0 \pm 3^\circ)$
$0.25 \leq H_s/\lambda < 0.3$	$(0 \pm 3^\circ, 102^\circ \sim 154^\circ, 0 \pm 3^\circ)$
$0.3 \leq H_s/\lambda < 0.4$	$(0 \pm 3^\circ, 102^\circ \sim 153^\circ, 0 \pm 3^\circ)$

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【請求項 4 3】

前記圧電性基板が、オイラー角 $(0 \pm 3^\circ, 104^\circ \sim 150^\circ, 0 \pm 3^\circ)$ の LiTaO_3 基板であり、前記第 1、第 2 絶縁物層が SiO_2 膜からなり、その合計の規格化膜厚 H_s/λ が $0.10 \sim 0.40$ の範囲にあり、

前記 A1 よりも密度の大きい金属が密度 $5000 \sim 15000 \text{ kg/m}^3$ 及びヤング率 $2.0 \times 10^{11} \sim 4.5 \times 10^{11} \text{ N/m}^2$ あるいは横波音速が $2800 \sim 3500 \text{ m/s}$ の金属からなり、前記電極の膜厚を H 、弾性表面波の波長を λ としたときに、規格化膜厚 H/λ が $0.008 \sim 0.06$ の範囲にある、請求項 1、4～6 のいずれかに記載の弾性表面波装置。

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【請求項 4 4】

前記金属が Ni である、請求項 4 3 に記載の弾性表面波装置。

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【請求項 4 5】

前記電極の規格化膜厚 H/λ が $0.02 \sim 0.06$ の範囲にある、請求項 4 4 に記載の弾性表面波装置。

【請求項 4 6】

前記電極の規格化膜厚 H/λ が $0.027 \sim 0.06$ の範囲にある、請求項 4 4 に記載の弾性表面波装置。

【請求項 4 7】

前記 LiTaO_3 基板のオイラー角と、前記 SiO_2 膜の合計の規格化膜厚 H_s/λ とが、下記の表 1 4 に示す組み合わせのいずれかである、請求項 4 4 に記載の弾性表面波装置。

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【表 1 4】

SiO ₂ 膜厚	オイラー角
0.1～0.2	(0±3°, 106° ～ 140°, 0±3°)
0.2～0.3	(0±3°, 105° ～ 137°, 0±3°)
0.3～0.4	(0±3°, 104° ～ 133°, 0±3°)

【請求項 4 8】

前記金属がMoからなる、請求項 4 8 に記載の弾性表面波装置。

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【請求項 4 9】

前記電極の規格化膜厚 H/λ が 0.017～0.06 の範囲にある、請求項 4 8 に記載の弾性表面波装置。

【請求項 5 0】

前記電極の規格化膜厚 H/λ が 0.023～0.06 の範囲にある、請求項 4 8 に記載の弾性表面波装置。

【請求項 5 1】

前記 SiTaO_3 基板のオイラー角と、前記 SiO_2 膜の合計の規格化膜厚 HS/λ とが下記の表 1 5 に示す組み合わせのいずれかである、請求項 4 8 に記載の弾性表面波装置。

【表 1 5】

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SiO ₂ 膜厚	オイラー角
0.1～0.2	(0±3°, 107° ～ 141°, 0±3°)
0.2～0.3	(0±3°, 104° ～ 141°, 0±3°)
0.3～0.4	(0±3°, 104° ～ 138°, 0±3°)

【請求項 5 2】

前記電極が、Alよりも密度の大きい金属もしくは合金からなる主たる電極層と、他の金属からなる少なくとも1つの電極層との積層膜からなり、該電極の平均密度 ρ と、前記 Alよりも密度の大きい金属の密度を ρ_0 とした場合、 $\rho_0 \times 0.7 \leq \rho \leq \rho_0 \times 1.3$ である、請求項 1, 4～6 のいずれかに記載の弾性表面波装置。

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【請求項 5 3】

前記第 2 絶縁物層表面の凹凸が、前記電極の膜厚の 30 % 以下である、請求項 1～5 2 のいずれかに記載の弾性表面波装置。

【請求項 5 4】

弾性表面波として漏洩タイプの弾性表面波を用いることを特徴とする、請求項 1～5 3 のいずれかに記載の弾性表面波装置。

【請求項 5 5】

圧電性基板を用意する工程と、

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前記圧電性基板の片面の全面に第 1 絶縁物層を形成する工程と、

少なくとも1つの電極を有する電極パターンを形成するためのレジストパターンを用いて前記電極が形成される部分の第 1 絶縁物層を除去するとともに、残りの領域に第 1 絶縁物層とレジストとの積層構造を残留させる工程と、

前記第 1 絶縁物層が除去されている領域に、Alよりも高密度の金属または該金属を主成分とする合金からなる電極膜を第 1 絶縁物層と略等しい厚みに形成して少なくとも1つの電極を形成する工程と、

前記第 1 絶縁物層上に残留しているレジストを除去する工程と、

前記第 1 絶縁物層及び電極上を被覆するように第 2 絶縁物層を形成する工程とを備える、弾性表面波装置の製造方法。

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【請求項56】

前記電極を構成している金属もしくは合金の密度が、前記第1絶縁物層の密度の1.5倍以上である、請求項55に記載の弾性表面波装置の製造方法。

【請求項57】

圧電性基板を用意する工程と、

前記圧電性基板の片面の全面において第1絶縁物層を形成する工程と、

少なくとも1つの電極パターンを形成するためのレジストパターンを用いて前記電極が形成される部分の領域の第1絶縁物層を除去し、残りの領域に第1絶縁物層とレジストとの積層構造を残留させる工程と、

前記第1絶縁物層が除去されている領域に、電極を形成するための金属もしくは合金膜を形成して電極を形成する工程と、

前記電極を形成した後に、該電極を構成する金属もしくは合金よりも耐腐食性に優れた金属もしくは合金からなる保護金属膜を該電極の全面に形成して前記保護金属膜を前記第1絶縁物層の高さと略等しい高さに形成する工程と、

前記第1絶縁物層上のレジスト及び該レジスト上に積層されている保護金属膜を除去する工程と、

前記電極上に形成された保護金属膜及び前記第1絶縁物層を覆うように、第2絶縁物層を形成する工程とを備える、弾性表面波装置の製造方法。

【請求項58】

前記電極及び保護金属膜からなる積層構造の平均密度が、第1絶縁物層の密度の1.5倍以上となるように、前記電極構成金属もしくは合金と、前記保護金属膜を構成する金属もしくは合金が選ばれる、請求項57に記載の弾性表面波装置の製造方法。

【請求項59】

圧電性基板を用意する工程と、

前記圧電性基板上に電極を形成する工程と、

前記電極を覆うように絶縁物層を形成する工程と、

前記電極が存在する部分と存在しない部分の上方における絶縁物層の凹凸を平坦化する工程とを備える、弾性表面波装置の製造方法。

【請求項60】

前記平坦化工程が、エッチバック、逆スパッタまたは研磨により行われる、請求項59に記載の弾性表面波装置の製造方法。

【請求項61】

前記電極を構成する金属としてAu、Cu、Ag、W、Ta、Pt、Ni及びMo並びにこれらの金属を主成分とする合金からなる群から選択された1種を用い、前記絶縁物層としてSiO₂を用いる、請求項55～59に記載の弾性表面波装置の製造方法。

【発明の詳細な説明】

【0001】

【発明の属する技術分野】

本発明は、例えば共振子や帯域フィルタなどに用いられる弾性表面波装置及びその製造方法に関し、より詳細には、IDT電極を被覆するように絶縁物層が形成されている構造を備えた弾性表面波装置及びその製造方法に関する。

【0002】

【従来の技術】

移動体通信システムに用いられるDPXやRFフィルタでは、広帯域かつ良好な温度特性の双方が満たされることが求められている。従来、DPXやRFフィルタに使用されてきた弾性表面波装置では、36°～50°回転Y板X伝搬LiTaO₃からなる圧電性基板が用いられている。この圧電性基板は、周波数温度係数が-40～-30PPm/°C程度であった。温度特性を改善するために、圧電性基板上においてIDT電極を被覆するように正の周波数温度係数を有するSiO₂膜を成膜する方法が知られている。図109にこの種の弾性表面波装置の製造方法の一例を示す。

【0003】

図109(a)に示すように、圧電性基板51上に、IDT電極が形成される部分を除いてレジストパターン52が形成される。次に、図109(b)に示すように、全面にIDT電極を形成するための電極膜53が形成される。しかる後、レジスト剥離液を用いて、レジスト52及びレジスト52上に付着している金属膜が除去される。このようにして、図109(c)に示すように、IDT電極53Aが形成される。次に、図109(d)に示すように、IDT電極53Aを被覆するように、 SiO_2 膜54が成膜される。

【0004】

他方、上記周波数温度特性の改善とは別の目的で、弾性表面波装置のIDT電極を被覆するように絶縁性または反導電性の保護膜が形成されている弾性表面波装置の製造方法が下記特許文献1に開示されている。図110は、この先行技術に記載の表面波装置を示す模式的断面図である。弾性表面波装置61では、圧電基板62上に、AlまたはAlを主成分とする合金からなるIDT電極63が形成されている。IDT電極63の設けられている領域以外の領域には、絶縁性または反導電性の電極指間膜64が形成されている。また、IDT電極63及び電極指間膜64を被覆するように、絶縁性または反導電性の保護膜65が形成されている。この先行技術に記載の弾性表面波装置61では、上記電極指間膜64及び保護膜65が、 SiO_2 などの絶縁物やシリコンなどの反導電性材料により構成される旨が記載されている。ここでは、上記電極指間膜63の形成により、圧電基板61の有する焦電性に起因する電極指間の放電による特性の劣化が抑制されるとされている。

【0005】

他方、下記の特許文献2には、水晶またはニオブ酸リチウムからなる圧電基板上に、アルミニウムや金などの金属からなる電極が形成されており、さらに SiO_2 膜を形成した後、該 SiO_2 膜を平坦化してなる1ポート型弾性表面波伝共振子が開示されている。ここでは、平坦化により良好な共振特性が得られるとされている。

【0006】

【特許文献1】

特開平11-186866号公報

【特許文献2】

特開平6-258355号公報

【0007】

【発明が解決しようとする課題】

図109に示したように、従来の周波数温度特性を改善するために SiO_2 膜を成膜してなる弾性表面波装置の製造方法では、IDT電極53Aが存在する部分と、存在しない部分とで、 SiO_2 膜54の表面の高さが異なることになる。従って、上記 SiO_2 膜54表面の凹凸の存在により、挿入損失が劣化するという問題があった。また、IDT電極の膜厚が大きくなるにつれて、この凹凸は大きくなる。従って、IDT電極の膜厚を厚くすることができなかった。

【0008】

他方、文献1に記載の弾性表面波装置では、IDT電極63の電極指間に電極指間膜64が形成された後に、保護膜65が形成されている。従って、保護膜65の表面を平坦化することができる。

【0009】

しかしながら、文献1に記載の構成では、IDT電極63はAlまたはAlを主成分とする合金により構成されていた。このIDT電極63に接するように電極指間膜64が形成されていたが、IDT電極63において十分な反射係数を得ることができなかった。そのため、例えば共振特性などにリップルが生じがちであるという問題があった。

【0010】

さらに、文献1に記載の製造方法では、保護膜65を形成するに先だち、電極指間膜64上に形成されたレジストをレジスト剥離液を用いて除去しなければならぬが、この際に

、IDT電極63がレジスト剥離液で腐食される恐れがあった。従って、IDT電極を構成する金属として、腐食され易い金属を用いることができなかった。すなわち、IDT電極構成金属の種類に制約があった。

【0011】

他方、前述した特許文献2に記載の1ポート型弾性表面波共振子では、圧電基板として水晶またはニオブ酸リチウムを用いること、電極がアルミニウムまたは金などからなることが示されているものの、具体的な実施例では、水晶基板上にAlからなる電極を形成した例のみが示されている。すなわち、他の基板材料や他の金属材料を用いた弾性表面波装置については特に言及されていない。

【0012】

本発明の目的は、上述した従来技術の現状に鑑み、IDT電極の電極指間及びIDT電極上に絶縁物層が形成されている弾性表面波装置及びその製造方法であって、IDT電極の反射係数が十分に大きく、共振特性などに表れるリップルによる特性の劣化が生じ難く、従って、良好な共振特性やフィルタ特性を有する弾性表面波装置及びその製造方法を提供することにある。

【0013】

本発明の他の目的は、IDT電極の反射係数が十分に大きく良好な特性を有するだけでなく、IDT電極を構成する金属材料の選択の制約が少なく、IDT電極の腐食による悪影響が生じ難い弾性表面波装置及びその製造方法を提供することにある。

【0014】

本発明のさらに他の目的は、IDT電極の反射係数が十分に大きく、良好な特性を有し、かつIDT電極の腐食による特性の劣化が生じ難いだけでなく、さらに周波数温度特性が良好な弾性表面波装置及びその製造方法を提供することにある。

【0015】

【課題を解決するための手段】

上述したように、特許文献2では、 SiO_2 膜を平坦化することにより良好な共振特性が得られることが示されている。そこで、本願発明者らは、広帯域のフィルタを得るべく、圧電基板として、電気機械結合係数が大きな LiTaO_3 基板を用い、その他は特許文献2に記載の構造と同様にして1ポート型弾性表面波共振子を作製し、特性を調査した。すなわち、 LiTaO_3 基板上に、Alからなる電極を形成し、 SiO_2 膜を形成し、該 SiO_2 膜の表面を平坦化した。しかしながら、 SiO_2 膜を形成した後、特性が大きく劣化し、実用し得るものではないことを見出した。

【0016】

電気機械結合係数が水晶に比べて大きい LiTaO_3 基板や LiNbO_3 基板を用いると、比帯域幅は格段に大きくなる。しかしながら、本願発明者らが詳細な検討を行った結果、図2及び図3に示すように、 LiTaO_3 基板上にAlからなる電極を形成し、さらに SiO_2 膜を形成した場合、 SiO_2 膜の表面を平坦化することにより、反射係数が0.02程度まで激減することがわかった。なお、図2及び図3は、オイラー角(0° , 12.6° , 0°)の LiTaO_3 基板上にアルミニウム、金または白金からなるIDT電極を種々の厚みで形成し、さらに SiO_2 膜を形成してなる弾性表面波装置の電極膜厚 H/λ と、反射係数との関係を示す図である。なお、図2及び図3における実線は SiO_2 膜の表面を図2及び図3中に模式的に示すように平坦化していない場合の反射係数の変化を示し、破線は SiO_2 膜の表面を平坦化した場合の反射係数の変化を示す。

【0017】

図2及び図3から明らかなように、従来のAlからなる電極を用いた場合には、 SiO_2 膜の表面を平坦化することにより、電極膜厚の如何に関わらず反射係数は0.02程度まで激減することがわかる。このため、十分なストップバンドが得られなくなり、反共振周波数近傍に鋭いリップルが生じると考えられる。

【0018】

また、従来、反射係数は電極膜厚が増大するにつれて大きくなることが知られている。し

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かしながら、図2及び図3から明らかなように、Alからなる電極を用いた場合には、電極の膜厚を大きくしたとしても、 SiO_2 膜の表面が平坦化された場合には、反射係数は増大しないことがわかる。

【0019】

これに対して、図2及び図3から明らかなように、AuやPtからなる電極を形成した場合には、 SiO_2 膜の弾性表面波を平坦化した場合においても、電極の膜厚が増大するにつれて、反射係数が大きくなることがわかる。本願発明者らは、このような知見に基づき、種々検討した結果、本発明をなすに至ったものである。

【0020】

本願の第1の発明によれば、圧電性基板と、前記圧電性基板上に形成されており、Alよりも高密度の金属または該金属を主成分とする合金からなる少なくとも1つのIDT電極と、前記少なくとも1つのIDT電極が形成されている領域を除いた残りの領域において、前記IDT電極と略等しい膜厚に形成された第1絶縁物層と、前記IDT電極及び第1絶縁物層を被覆するように形成された第2絶縁物層とを備え、上記IDT電極の密度が、第1絶縁物層の密度の1.5倍以上とされている弾性表面波装置が提供される。第1の発明では、共振特性やフィルタ特性などに表れるリップルが帯域外に移動されると共に、リップルが抑圧される。従って、良好な特性を実現することができる。

【0021】

本願の第2の発明の広い局面によれば、圧電性基板と、前記圧電性基板上に形成された少なくとも1つのIDT電極と、前記IDT電極上に形成されており、かつIDT電極を構成する金属もしくは合金よりも耐腐食性に優れた金属もしくは合金からなる保護金属膜と、前記少なくとも1つのIDT電極が形成されている領域を除いた残りの領域において、前記IDT電極と保護金属膜との合計の膜厚と略等しい膜厚を有するように形成された第1絶縁物層と、前記保護金属膜及び第1絶縁物層を被覆するように形成された第2絶縁物層とを備える、弾性表面波装置が提供される。

【0022】

第2の発明のある特定の局面では、上記IDT電極及び保護金属膜からなる積層構造の平均密度が、第1絶縁物層の密度の1.5倍以上とされており、それによって共振特性やフィルタ特性上に表れる不要リップルが帯域外にシフトされ、かつ共振される。

【0023】

第1、第2の発明のある特定の局面では、上記第1、第2の絶縁物層が SiO_2 により形成され、それによって周波数温度特性が良好な弾性表面波装置を提供することができる。

【0024】

第1、第2の発明に係る弾性表面波装置は、好ましくは、弾性表面波の反射を利用した弾性表面波装置である。弾性表面波の反射を利用する構造としては、特に限定されず、圧電性基板の対向2端面の反射を利用した端面反射型弾性表面波装置が構成されてもよく、あるいはIDTの弾性表面波伝搬方向外側に反射器を設けた弾性表面波装置であってもよい。

【0025】

第1、第2の発明に係る弾性表面波装置は、様々な弾性表面波共振子や弾性表面波フィルタに用いることができる。このような弾性表面波共振子は、1ポート型共振子であってもよく、2ポート型共振子であってもよく、また弾性表面波フィルタは、2ポート型共振子フィルタであってもよく、ラダー型フィルタまたはラチス型フィルタなどであってもよい。

【0026】

第1、第2の発明に係る弾性表面波装置のある特定の局面では、上記電極がIDT電極である。IDT電極は、一方向性電極であってもよく、それによって挿入損失を低減することができる。

【0027】

また、上記電極は反射器であってもよい。

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第1、第2の発明に係る弾性表面波装置のある特定の局面では、上記電極が、IDT電極及び反射器電極である。

【0028】

第1、第2の発明のある特定の局面では、前記圧電性基板が、オイラー角($0 \pm 3^\circ$, $104^\circ \sim 140^\circ$, $0 \pm 3^\circ$)の LiTaO_3 基板であり、前記第1、第2の絶縁物層が SiO_2 より構成されており、第1、第2絶縁物層を構成している SiO_2 膜の合計膜厚を H_S 、弾性表面波の波長を λ としたときに、 H_S/λ が $0.08 \sim 0.45$ の範囲とされており、前記電極の厚みを H 、弾性表面波の波長を λ としたときに、電極の規格化膜厚 H/λ が、下記の式(1)を満たす値とされている。

$0.005 \leq H/\lambda \leq 0.00025 \times \rho^2 - 0.01056 \times \rho + 0.16473$ (但し、 ρ は電極の平均密度) 式(1) 10

【0029】

前述したように、第1の発明では、電極を構成する金属として、金属が用いられる。このような金属としては、Au、Ag、Cu、W、Ta、Pt、NiまたはMoなどが挙げられる。

【0030】

本発明においては、後述するように、これらの金属もしくはこれらの金属を主体とする合金、あるいはこれらの金属もしくは合金からなる主たる金属膜と、他の金属からなる少なくとも1層の金属膜との積層膜により電極が構成されてもよい。この場合、金属の種類に応じて電極の規格化膜厚 H/λ 及び圧電性基板のオイラー角及び第1、第2の絶縁物層を SiO_2 膜から構成した場合の該 SiO_2 膜の合計の規格化膜厚 H_S/λ が特定の範囲とされ、電気機械結合係数及び反射係数を高めることができ、かつ良好な周波数温度特性を実現することができる。また、上記各範囲を選択することにより、減衰定数の低下も図ることができる。

【0031】

本願の第3の発明は、第1の発明に係る弾性表面波装置の製造方法であって、圧電性基板を用意する工程と、前記圧電性基板の片面の全面に第1絶縁物層を形成する工程と、少なくとも1つのIDT電極を有する電極パターンを形成するためのレジストパターンを用いて前記IDT電極が形成される部分の第1絶縁物層を除去するとともに、残りの領域に第1絶縁物層とレジストとの積層構造を残留させる工程と、前記第1絶縁物層が除去されている領域に、Auよりも高密度の金属または該金属を主成分とする合金からなる電極膜を第1絶縁物層と略等しい厚みに形成して少なくとも1つのIDT電極を形成する工程と、前記第1絶縁物層上に残留しているレジストを除去する工程と、前記第1絶縁物層及びIDT電極上に被覆するように第2絶縁物層を形成する工程とを備えることを特徴とする。

【0032】

第3の発明に係る弾性表面波装置の製造方法においても、好ましくは、上記IDT電極を構成する金属もしくは合金の密度は、第1絶縁物層の密度の1.5倍以上とされ、共振特性やフィルタ特性上に表れる不要リップルが帯域外にシフトされ、かつ共振される。

【0033】

本願の第4の発明は、弾性表面波装置の製造方法であって、第2の発明に係る弾性表面波装置を得るためのものである。第4の発明は、圧電性基板を用意する工程と、前記圧電性基板の片面の全面において第1絶縁物層を形成する工程と、少なくとも1つのIDT電極パターンを形成するためのレジストパターンを用いて前記電極が形成される部分の領域の第1絶縁物層を除去し、残りの領域に第1絶縁物層とレジストとの積層構造を残留させる工程と、前記第1絶縁物層が除去されている領域に、IDT電極を形成するための金属もしくは合金膜を形成して、IDT電極を形成する工程と、前記IDT電極を形成した後に、該IDT電極を構成する金属もしくは合金よりも耐腐食性に優れた金属もしくは合金からなる保護金属膜を該IDT電極の全面に形成して前記保護金属膜を前記第1絶縁物層の高さと略等しい高さに形成する工程と、前記第1絶縁物層上のレジスト及び該レジスト上に積層されている保護金属膜を除去する工程と、前記IDT電極上に形成された保護金属 40 50

膜及び前記第1絶縁物層を覆うように、第2絶縁物層を形成する工程とを備えることを特徴とする。

【0034】

第4の発明においても、第2の発明と同様に、IDT電極及び保護金属膜からなる積層構造の平均密度は、好ましくは、第1絶縁物層の密度の1.5倍以上とされ、共振特性やフィルタ特性上に表れる不要リップルが帯域外にシフトされ、かつ共振される。

【0035】

本願の第5の発明は、圧電性基板を用意する工程と、前記圧電性基板上に電極を形成する工程と、前記電極を覆うように絶縁物層を形成する工程と、前記電極が存在する部分と存在しない部分の上方における絶縁物層の凹凸を平坦化する工程とを備える、弾性表面波装置の製造方法である。

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【0036】

第5の発明においては、好ましくは、上記平坦化工程は、エッチバック、逆スパッタまたは研磨により行われる。

【0037】

【発明の実施の形態】

以下、図面を参照しつつ、本発明の具体的な実施例を説明することにより、本発明を明らかにする。

【0038】

図1及び図6を参照して、本発明の第1の実施例に係る弾性表面波装置の製造方法を説明する。

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図1(a)に示すように、まず、圧電性基板として、LiTaO₃基板1を用意する。本実施例では、36°Y板X伝搬、オイラー角 ϕ (0°, 126°, 0°)のLiTaO₃基板が用いられる。もっとも、圧電性基板としては、他の結晶方位のLiTaO₃基板を用いてもよく、あるいは他の圧電単結晶からなるものを用いてもよい。また、絶縁性基板上に圧電性薄膜を積層してなる圧電性基板を用いてもよい。なお、オイラー角 ϕ , θ , ψ の θ =カット角+90°の関係がある。

【0039】

LiTaO₃基板1上に、全面に第1絶縁物層2を形成する。本実施例では、第1絶縁物層2は、SiO₂膜により形成されている。

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第1絶縁物層2の形成方法は、印刷、蒸着、またはスパッタリングなどの適宜の方法により行われ得る。また、第1絶縁物層2の厚みは、後で形成されるIDT電極の厚みと等しくされている。

【0040】

次に、図1(b)に示すように、フォトリソグラフィ技術を用いて、レジストパターン3を形成する。レジストパターン3では、IDTが形成される領域を除いてレジストが位置するようにレジストパターン3が構成されている。

【0041】

次に、図1(c)に矢印で示すようにイオンビームを照射する反応性イオンエッチング法(RIE)などにより、第1絶縁物層2の内、レジスト3の下方に位置している部分を除いた残りの部分を除去する。

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【0042】

フッ素系のガスによるRIEによってSiO₂をエッチングした場合、重合反応により残が生じる場合がある。この場合、RIEを行った後、BHF(バッファードフッ酸)等により処理することに対応できる。

【0043】

しかる後、Cu膜とTi膜を、第1絶縁物層2と等しい厚みに成膜する。図1(d)に示すように、第1絶縁物層2が除去されている領域、すなわちIDTが形成される領域にCu膜4が付与され、同時にレジストパターン3上にもCu膜4が付与される。次に、全面保護金属膜としてTi膜5を形成する。図1(e)に示すように、Ti膜5は、IDT電

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極4Aの上面と、レジストパターン3上のCu膜4上に付与されることになる。従って、IDT電極4Aは、側面が第1絶縁物層2で被覆され、上面がTi膜5により被覆されている。このようにして、IDT電極4Aと保護金属膜とが形成され、IDT電極4Aの厚みと保護金属膜としてのTi膜5の厚みの合計の厚みと第1絶縁物層2の厚みとが同じ厚みを有するように構成される。

【0044】

しかる後、レジスト剥離液を用い、レジストパターン3を除去する。このようにして、図1(f)に示すように、第1絶縁物層2が設けられている領域を除いた残りの領域にIDT電極4Aが形成されており、IDT電極4Aの上面がTi膜5により被覆されている構造が得られる。

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【0045】

しかる後、図1(g)に示すように、全面に第2絶縁物層6としてSiO₂膜を形成する。

このようにして、図6に示す1ポート型の弾性表面波共振子11を得た。

【0046】

なお、図1(a)～(g)では、IDT電極4Aが形成されている部分のみが抜き出されて説明された。しかしながら、図6に示されているように、弾性表面波共振子11は、IDT電極4Aの弾性表面波伝搬方向両側に反射器12、13を備えている。反射器12、13もまた、IDT電極4Aと同じ工程により形成される。

【0047】

上記実施例では、1ポート型弾性表面波共振子11が構成されているため、LiTaO₃基板1上に、1個のIDT電極4Aが形成されていたが、弾性表面波装置の用途に応じて、複数のIDT電極が形成されてもよく、また上記のように反射器がIDTと同一工程により形成されてもよく、反射器が設けられずともよい。

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【0048】

比較のために、図109に示した従来のSiO₂膜を有する弾性表面波装置の製造方法に準じて、1ポート型弾性表面波共振子を作製した。もっとも、この比較例においても、基板材料としては、36°回転Y板X伝搬(オイラー角で(0°, 126°, 0°))のLiTaO₃基板を用い、IDT電極はCuにより形成した。図109に示した製造方法から明らかなように、IDT電極53Aが形成された後に、SiO₂膜54が形成されるため、SiO₂膜54の表面に凹凸が生じざるを得なかった。比較例において、CuからなるIDT電極の規格化膜厚 h/λ (h はIDT電極の厚み、 λ は弾性表面波の波長)を0.042とし、SiO₂膜の規格化膜厚 HS/λ (HS はSiO₂膜の厚み)を、0.11、0.22及び0.33とした場合のインピーダンス特性及び位相特性を図4に示す。図4から明らかなように、SiO₂膜の規格化膜厚 HS/λ が大きくなるにつれて、反共振点におけるインピーダンスと共振点におけるインピーダンスとの比であるインピーダンス比が小さくなることがわかる。

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【0049】

また、図5は、比較例で製作された弾性表面波共振子のSiO₂膜の規格化膜厚 HS/λ と、共振子のMF(Figure of Merit)との関係を示す。図5から明らかなように、SiO₂膜の膜厚が厚くなるにつれて、MFが低下することがわかる。

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【0050】

すなわち、図109に示した従来法に準じて、IDT電極及びSiO₂膜を形成した場合、たとえCuによりIDT電極を形成したとしても、SiO₂膜の膜厚が厚くなるにつれて、特性が大きく劣化した。これは、SiO₂膜表面に前述した凹凸が生じざるを得ないことによると考えられる。

【0051】

これに対して、本実施例の製造方法によれば、SiO₂膜の膜厚を増加させた場合でも特性の劣化が生じ難いこと、図7～9に示す。

図7は、上記実施例に従って弾性表面波共振子11を得た場合のSiO₂膜の厚み、すな

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わち、第2絶縁物層6の厚みを変化させた場合のインピーダンス特性及び位相特性の変化を示す図である。また、図8及び図9の破線は、それぞれ、実施例において SiO_2 膜の膜厚 H_S/λ を変化させた場合の共振子の γ 及びMFの変化を示す図である。

【0052】

なお、図8及び図9においては、上記比較例の結果を、実線で示す。

図7を、図4と比較すれば明らかなように、上記実施例では、比較例の場合に比べて、 SiO_2 膜の規格化膜厚 H_S/λ を増加させても、インピーダンスの低下が生じ難いことがわかる。

【0053】

また、図8及び図9の結果から明らかなように、比較例に比べて、実施例の製造方法によれば、 SiO_2 膜の規格化膜厚 H_S/λ の増加に伴う特性の劣化が抑制されることがわかる。

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【0054】

すなわち、本実施例の製造方法によれば、上記のように SiO_2 膜の膜厚を増加させた場合であっても、インピーダンス比の低下が生じ難く、特性の劣化を抑制することができる。

【0055】

他方、図10は、 SiO_2 膜の膜厚と、比較例及び実施例の製造方法で得られた弾性表面波共振子の周波数温度特性TCFとの関係を示す図である。

図10において、実線が比較例、破線が実施例の結果を示す。

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【0056】

図10から明らかなように、実施例の製造方法によれば、 SiO_2 膜の膜厚を増加させた場合に、周波数温度特性TCFを膜厚増に依りて理想的に改善し得ることがわかる。

【0057】

従って、上記実施例の製造方法を採用することにより、特性の劣化が生じ難く、温度特性を効果的に改善し得る弾性表面波共振子を提供し得ることがわかる。

加えて、本実施例の製造方法では、IDT電極は、A1よりも高密度のCuにより構成されている。従って、IDT電極4Aは十分な反射係数を有し、共振特性上に表れる所望でないリップルを抑制することができる。これを、以下において説明する。

【0058】

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Cuに代えてAl膜を用いたことを除いては、上記実施例と同様にして第2の比較例の弾性表面波共振子を作製した。但し、 SiO_2 膜の規格化膜厚 H_S/λ は0.08とした。すなわち、第1の絶縁物層の厚みの規格化膜厚を0.08とした。このようにして得られた弾性表面波共振子のインピーダンス及び位相特性を図11に実線で示す。

【0059】

また、 SiO_2 膜を形成しなかったことを除いては、第2の比較例と同様にして構成された弾性表面波共振子のインピーダンス及び位相特性を図11に破線で示す。

【0060】

図11の実線から明らかなように、上記実施例の製造方法に従ったとしても、IDT電極をAlで形成し、かつ SiO_2 膜を形成した場合には、図11の矢印Aで示す大きなリップルが共振点と反共振点との間において表れることがわかる。また、このようなリップルは、 SiO_2 を有しない弾性表面波共振子では表れていないことがわかる。

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【0061】

従って、 SiO_2 膜の形成により周波数温度特性の改善等を図ろうとしても、AlによりIDT電極を形成した場合には、上記リップルAが表れ、特性の劣化を引き起こすことがわかる。本願発明者は、この点につきさらに検討した結果、IDT電極として、Alよりも高密度の金属を用いれば、IDT電極の反射係数を高めることができ、それによって上記リップルAを抑制し得ることを見出した。

【0062】

すなわち、上記実施例と同様の製造方法に従って、但し、IDT電極4を構成する金属の

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密度を種々異ならせ、上記実施例と同様に弾性表面波共振子を作製した。このようにして得られた弾性表面波共振子のインピーダンス特性を図12(a)～(e)に示す。図12(a)～(e)は、それぞれ、IDT電極及び保護金属膜の積層構造の平均密度 ρ_1 の第1絶縁物層の密度 ρ_2 に対する比 ρ_1/ρ_2 が、2.5、2.0、1.5、1.2及び1.0の場合の結果を示す。

【0063】

図12(a)～(e)から明らかなように、図12(a)～(c)では、上記リップルAが帯域外にシフトされ、さらに図12(a)では、上記リップルAが著しく抑圧されていることがわかる。

【0064】

従って、図12の結果から、IDT電極及び保護金属膜の積層構造の第1絶縁物層に対する密度比を1.5倍以上とすれば、上記リップルAを共振周波数－反共振周波数の帯域の外側にシフトさせ、良好な特性の得られることがわかる。また、より好ましくは、上記密度比を2.5倍以上とすれば、リップル自体を小さくし得ることがわかる。

【0065】

図12(a)～(e)では、上記実施例に従って、IDT電極4A上に、Ti膜が積層されていたため、上記平均密度が用いられたが、本発明においては、IDT電極4A上に、保護金属膜が設けられずともよい。その場合には、IDT電極4Aの厚みを第1の絶縁物層の厚みと同じにして、IDT電極の密度の第1絶縁物層の密度に対する比を1.5倍以上とすることが好ましく、より好ましくは2.5倍以上とすればよく、上記と同様の効果の得られることが確かめられた。

【0066】

従って、SiO₂膜によりIDT電極を被覆してなる弾性表面波共振子において、IDT電極の密度あるいはIDT電極と保護金属膜との積層体の平均密度を、IDT電極の側方に位置する第1絶縁物層の密度よりも大きくすれば、IDT電極の反射係数を高めることができ、それによって共振点－反共振点間に表れる特性の劣化を抑制し得ることがわかる。

【0067】

なお、Alより高密度の金属もしくは合金としては、Cuの他、Ag、Auなどやこれらを主体とする合金が挙げられる。

また、好ましくは、上記実施例のように、IDT電極上に、保護金属膜を積層した構造とすれば、図1(a)～(g)に示した製造方法から明らかなように、レジストパターン8を剥離する際に、IDT電極4Aの側面が第1絶縁物層2により覆われており、かつ上面が保護金属膜6により覆われているため、IDT電極4Aの腐食を防止することができる。よって、より一層良好な特性を有する弾性表面波共振子を提供し得ることがわかる。

【0068】

さらに、SiO₂以外のSiO_xN_yなどの他の温度特性改善効果のある絶縁性材料により第1、第2の絶縁物層を形成してもよい。また、第1、第2の絶縁物層は異なる絶縁性材料で構成されてもよく、上記のように等しい材料で構成されてもよい。

【0069】

図13は、オイラー角(0°、126°、0°)のLiTaO₃基板上に、様々な厚みで様々な金属を用いてIDT電極を形成した場合のIDTの規格化膜厚 H/λ と、電気機械結合係数の関係を示す図である。

【0070】

図13から得られる、Alに比べて電気機械結合係数が大きくなる電極の規格化膜厚を各金属について調べたところ、図14に示す結果が得られた。すなわち、図14は、上記LiTaO₃基板上に、様々な密度の金属からなるIDT電極を形成した場合に、上述したようにAlからなるIDT電極を形成した場合に比べて電気機械結合係数が大きくなる電極膜厚範囲を示す図である。

【0071】

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図14において、各金属からなる電極の膜厚範囲のうち上限が、A1よりも電気機械結合係数が大きくなる範囲の限界値であり、各金属の電極膜厚範囲の下限は作製限界を示す。電気機械結合係数の大きな電極膜厚の範囲を γ 、密度を ρ として上限を二次式で近似すると、 $\gamma = 0.00025 \times^2 - 0.01056 \times + 0.16478$ となる。

【0072】

従って、後述の各電極材料別の具体的な実施例の説明から明らかなように、 $14^\circ \sim 50^\circ$ 回転Y板X伝搬（オイラー角で $(0^\circ, 104^\circ \sim 140^\circ, 0^\circ)$ ）のLiTaO₃からなる圧電基板上に電極が形成されており、さらにSiO₂膜は規格化膜厚 $HS/\lambda 0.03 \sim 0.45$ の範囲で形成されている構造において、電極の規格化膜厚 H/λ が、 $0.005 \leq H/\lambda \leq 0.00025 \times \rho^2 - 0.01056 \times \rho + 0.16478$ 式(1)

を満たす場合、図14の結果から明らかなように電気機械結合係数を高めることができる。なお、 ρ は電極の平均密度を示す。

【0073】

本発明においては、電極は、上述したアルミニウムよりも密度の高い金属を用いて構成されていることを特徴とする。この場合、電極は、アルミニウムよりも密度の高い金属から構成されていてもよく、あるいはアルミニウムを主体とする合金で構成されていてもよい。また、アルミニウムもしくはアルミニウムを主成分とする合金からなる主たる金属膜と、該金属膜と異なる金属からなる従たる金属膜の積層構造で構成されていてもよい。積層膜により電極が構成されている場合、電極の平均密度を ρ 、主たる電極層の金属の密度を $\rho 0$ とした場合、 $\rho 0 \times 0.7 \leq \rho \leq \rho 0 \times 1.3$ を満足する平均密度であればよい。

【0074】

また、本発明においては、上記のように第2絶縁物層の表面が平坦化されるが、この平坦化とは、電極の膜厚の30%以下の凹凸を有するものであればよい。30%を超えると、平坦化による効果が十分に得られないことがある。

【0075】

さらに、上記のように第2絶縁物層の平坦化は、様々な方法で行われる。例えば、エッチバックによる平坦化方法、逆スパッタ効果による斜入射効果を利用した平坦化方法、絶縁物層表面を研磨する方法、あるいは電極を研磨する方法などが挙げられる。これらの方法は2種以上が併用されてもよい。これらの方法の詳細を、図102～図105を説明する。

【0076】

図102(a)～(c)は、エッチバック方法により絶縁物層表面を平坦化する方法である。まず、図102(a)に示すように、圧電性基板41上に、電極42が形成され、しかる後絶縁物層43が形成される。図102(b)に示すように、絶縁物層43上にレジスト44がスピンコーティング等により形成される。レジスト44の表面は平坦である。従って、この状態から、反応性イオンエッチングによりエッチングすることにより、すなわちエッチバックにより、SiO₂などからなる絶縁物層43の表面を平坦化することができる(図102(c))。

【0077】

図103(a)～(d)は、逆スパッタ法を説明するための各模式的断面図である。ここでは、圧電性基板41上に電極42が形成され、しかる後絶縁物層43が形成される。そして、アルゴンイオンなどをスパッタリングにより絶縁物層43の表面に照射する。このイオンは、基板41をスパッタするために用いられている。イオンが基板に衝突し、スパッタリングを行う場合、平坦な面に入射するよりも、斜めの面に入射する場合の方が大きなスパッタ効果が得られる。これは、斜入射効果として知られている。この効果により、絶縁物層43の表面が、図103(b)～(d)に示すように、スパッタリングを進めるに従って平坦化される。

【0078】

図104(a)及び(b)は、絶縁物層を研磨することにより平坦化する方法を説明する

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ための模式的断面図である。図104(a)に示すように、基板41上に、電極42及び絶縁物層43を形成した後、機械的または化学的に研磨することにより、絶縁物層43の表面を平坦化することができる。

【0079】

図105(a)～(c)は、電極を研磨することにより平坦化を図る方法である。ここでは、図105(a)に示すように、基板41上に、第1絶縁物層45を形成した後、電極材料からなる金属膜42Aを全面に蒸着等により形成される。しかる後、図105(b)に示すように、金属膜42Aを機械的または化学的に研磨することにより、電極42と、電極42が設けられている領域の周囲の領域に形成された第1絶縁物層45を形成する。このようにして、第1絶縁物層45及び電極42の上面が面一とされ、平坦化される。しかる後、図105(c)に示すように、第2絶縁物46を形成することにより、表面が平坦な絶縁物層を形成することができる。

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【0080】

本発明は、様々な弾性表面波装置に適用することができる。このような弾性表面波装置の例を、図106(a)、(b)～図108に示す。図106(a)及び(b)は、それぞれ、1ポート型弾性表面波共振子47及び2ポート型弾性表面波共振子48の電極構造を示す模式的平面図である。また、図106(b)に示す2ポート型弾性表面波共振子48と同じ電極構造を用いて2ポート型弾性表面波共振子フィルタを構成してもよい。

【0081】

さらに、図107及び図108は、それぞれ、ラダー型フィルタ及びラチス型フィルタの電極構造を示す模式的平面図である。図107及び図108に示すラダー型フィルタ49a及びラチス型フィルタ49bのような電極構造を圧電性基板上に形成することにより、本発明に従ってラダー型フィルタ及びラチス型フィルタを構成することができる。

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【0082】

もっとも、本発明は、図106及び図107に示した電極構造を有する弾性表面波装置に限らず、様々な弾性表面波装置に適用することができる。

また、本発明に係る弾性表面波装置では、好ましくは、漏洩弾性波を用いた弾性表面波装置が構成される。特開平6-164806号公報には、Auなどの重い金属からなる電極を有する弾性表面波装置であって、伝搬減衰がないラブ波を用いた弾性表面波装置が開示されている。ここでは、重い金属を電極として用いることにより、伝搬する弾性表面波の音速が基板の遅い横波バルク波よりも遅くされ、それによって漏洩成分がなくなり、非漏洩の弾性表面波としてのラブ波が利用されている。

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【0083】

しかしながら、上記ラブ波では、音速が必然的に遅くなり、それに伴ってIDTのピッチが小さくならざるを得ない。従って、加工の難易度が高くなり、加工精度が劣化する。加えて、IDTの線幅も小さくなり、抵抗による損失も増大する。従って、損失が大きくならざるを得ない。

【0084】

これに対して、本発明では、上記のようなラブ波を用いた弾性表面波装置とは異なり、A1よりも重い金属からなる電極を用いているにも関わらず、音速の速い漏洩弾性表面波を好適に利用することができる。その場合であっても伝搬損失の低減を図ることができる。従って、低損失の弾性表面波装置を構成することができる。

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【0085】

以下、上述した結果をふまえて、電極をA1よりも密度の大きい金属で構成した場合の個々の例につき、金属材料ごとに説明を行うこととする。

なお、本発明で用いられるA1よりも密度の大きい金属とは、(1)密度 $15000 \sim 23000 \text{ kg/m}^3$ 及びヤング率 $0.5 \times 10^{11} \sim 1.0 \times 10^{11} \text{ N/m}^2$ あるいは横波音速が $1000 \sim 2000 \text{ m/s}$ である金属、例えばAu、(2)密度 $5000 \sim 15000 \text{ kg/m}^3$ 及びヤング率 $0.5 \times 10^{11} \sim 1.0 \times 10^{11} \text{ N/m}^2$ あるいは横波音速が $1000 \sim 2000 \text{ m/s}$ である金属、例えばAg、(3)密度 $5000 \sim 1$

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5000 kg/m³ 及びヤング率 $1.0 \times 10^{11} \sim 2.05 \times 10^{11}$ N/m² あるいは横波音速が 2000 ~ 2800 m/s である金属、例えば Cu、(4) 密度 15000 ~ 23000 kg/m³ 及びヤング率 $2.0 \times 10^{11} \sim 4.5 \times 10^{11}$ N/m² あるいは横波音速が 2800 ~ 3500 m/s である金属、例えばタンゲステン、(5) 密度 15000 ~ 23000 kg/m³ 及びヤング率 $1.0 \times 10^{11} \sim 2.0 \times 10^{11}$ N/m² あるいは横波音速が 2000 ~ 2800 m/s である金属、例えばタンタル、(6) 密度 15000 ~ 23000 kg/m³ 及びヤング率 $1.0 \times 10^{11} \sim 2.0 \times 10^{11}$ N/m² あるいは横波音速が 1000 ~ 2000 m/s である金属、例えば白金、(7) 密度 5000 ~ 15000 kg/m³ 及びヤング率 $2.0 \times 10^{11} \sim 4.5 \times 10^{11}$ N/m² あるいは横波音速が 2800 ~ 3500 m/s である金属、例えば Ni, Mo が挙げられる。

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【0086】

〔電極が Au を主体とする実施例〕

図 15 は、本発明の他の実施例に係る弾性表面波装置としての縦結合共振子フィルタを説明するための平面図である。

【0087】

弾性表面波装置 21 は、LiTaO₃ 基板 22 の上面に、IDT 23a, 23b 及び反射器 24a, 24b を形成した構造を有する。また、IDT 23a, 23b 及び反射器 24a, 24b を覆うように SiO₂ 膜 15 が形成されている。なお、LiTaO₃ 基板 22 としては、25° ~ 58° 回転 Y 板 X 伝搬（オイラー角 (0°, 115° ~ 148°, 0°)）LiTaO₃ 基板が用いられる。この範囲外のカット角の回転 Y 板 X 伝搬 LiTaO₃ 基板では、減衰定数が大きく、TCF も悪化する。

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【0088】

IDT 23a, 23b 及び反射器 24a, 24b は、Al に比べて密度の高い金属により構成される。このような金属としては、Au, Pt, W, Ta, Ag, Mo, Cu, Ni, Co, Cr, Fe, Mn, Zn 及び Ti からなる群から選択された少なくとも 1 種の金属または該少なくとも 1 種を主成分とする合金が挙げられる。

【0089】

上記のように、Al に比べて密度の高い金属により IDT 23a, 23b 及び反射器 24a, 24b が構成されているため、IDT 23a, 23b 及び反射器 24a, 24b の膜厚を Al を用いた場合に比べて薄くした場合であっても、図 16、図 17 に示すように、電気機械結合係数及び反射係数を高めることができる。

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【0090】

そして、上記のように電極膜厚を薄くすることができる。SiO₂ 膜 25 の厚みについては、後述の実験例から明らかなように、弾性表面波の波長で規格化された膜厚 HS/λ が 0.03 ~ 0.45 の範囲であることが好ましい。なお、HS は第 1、第 2 絶縁物層を SiO₂ で構成した場合の合計の厚み、λ は弾性表面波の波長を示す。この範囲にすることで、SiO₂ 膜がない場合より減衰定数を大幅に小さくすることができ、低ロス化が可能となる。

【0091】

IDT を構成する材料によっても異なるが、例えば Au 膜からなる場合、IDT 23a, 23b の弾性表面波の波長で規格化された膜厚は 0.013 ~ 0.030 が好ましい。Au 膜が薄いとき、IDT が引き回り抵抗をもつので、より好ましくは 0.021 ~ 0.03 が好ましい。

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【0092】

本発明に係る弾性表面波装置では、上記のように、LiTaO₃ 基板 22 上に Al よりも密度の大きい金属により IDT 23a, 23b が構成されており、該 IDT 23a, 23b の電極膜厚を薄くすることができる。よって、良好な特性を有し、かつ SiO₂ 膜 25 の形成により良好な周波数温度特性が実現される。これを、具体的な例に基づき説明する。

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【0093】

36°回転Y板X伝搬、オイラー角 ϕ (0°, 126°, 0°)のLiTaO₃基板上に、AlからなるIDTを形成した場合、及びAu、Ta、Ag、Cr、W、Cu、Zn、Mo、NiからなるIDTの種々の膜厚で形成した場合の電気機械結合係数 K_{sa_w} 及び減衰定数(α)と反射係数 $|r_{ef}|$ の変化を図16、図18及び図17にそれぞれ示す。なお、数値計算はJ. J. Campbell and W. R. Jones: IEEE Trans. Sonics & Ultrason. SU-15, P209 (1968)の方法に従い、電極は全面一様として計算を行った。

【0094】

図16から明らかなように、AlからなるIDTにおいて、規格化された膜厚 H/λ が0.10の場合、電気機械結合係数 K_{sa_w} は約0.27である。なお、Hは厚み、 λ は弾性表面波の波長を示す。これに対して、Au、Ta、Ag、Cr、W、Cu、Zn、Mo、NiからなるIDTでは H/λ を0.013~0.035の範囲とした場合、より大きな電気機械結合係数 K_{sa_w} を実現することができる。しかしながら、図18から明らかなように、膜厚 H/λ の如何に関わらず、AlからなるIDTでは減衰定数 α がほぼ0であるのに対し、Au、Ta、Ag、Cr、W、Cu、Zn、Mo、NiからなるIDTでは、減衰定数が非常に大きくなる。

【0095】

図25は、オイラー角 ϕ (0°, θ , 0°)のLiTaO₃基板上に、AuからなるIDT及びSiO₂膜を形成した構造における、 θ と、電気機械結合係数との関係を示す図である。ここでは、AuからなるIDTの規格化膜厚を、0.022、0.025及び0.030とした場合、並びにSiO₂膜の規格化膜厚 H_s/λ を、0.00(SiO₂膜を成膜せず)、0.10、0.20、0.30及び0.45と変化させた。

【0096】

図25から明らかなように、SiO₂膜が厚くなるに連れて、電気機械結合係数 K_{sa_w} が小さくなることがわかる。また、後述するように、SiO₂膜による特性の劣化を抑制するために、IDTの膜厚を薄くした場合を考えてみる。前述の図16から明らかなように、従来のAlからなるIDTにおいて規格化膜厚を0.04まで薄くした場合、SiO₂膜が形成されていない場合でも、電気機械結合係数 K_{sa_w} は0.245と小さくなる。また、AlからなるIDTの規格化膜厚を0.04とし、SiO₂膜を形成した場合に

【0097】

これに対して、図25から明らかなように、AuからなるIDTを形成し、SiO₂膜を形成した構造では、オイラー角の θ を128.5°以下とすることにより、SiO₂膜の規格化膜厚 H_s/λ を0.45程度とした場合であっても、電気機械結合係数 K_{sa_w} は0.245以上となることがわかる。また、規格化膜厚が0.30程度のSiO₂膜を形成した場合には、オイラー角の θ を132°以下とすることにより、電気機械結合係数 K_{sa_w} を0.245以上とすることができる。なお、後述するように、オイラー角の θ が115°よりも小さい場合には、減衰定数が大きくなり、実用的ではない。従って、25°~42°回転Y板X伝搬(オイラー角 ϕ (0±3°, 115°~132°, 0±3°))、より好ましくは25°~38.5°回転Y板X伝搬(オイラー角 ϕ (0±3°, 115°~128.5°, 0±3°))のLiTaO₃基板を用いることが好適であることがわかる。

【0098】

他方、36°回転Y板X伝搬、オイラー角 ϕ (0°, 126°, 0°)のLiTaO₃基板の周波数温度特性(TCF)は-30~-40PPM/°Cであり、十分ではない。この周波数温度特性TCFを±20PPM/°Cの範囲内となるように改善するために、36°回転Y板X伝搬、オイラー角 ϕ (0°, 126°, 0°)のLiTaO₃基板上に、AuからなるIDTを形成し、さらにSiO₂膜を種々の膜厚で形成した場合の周波数温度特性の変化を図19に示す。なお、図19において、○は理論値を示し、×は実験値を示す

。ここでは、AuからなるIDTの規格化膜厚は $H/\lambda = 0.020$ である。

【0099】

図19から明らかなように、 SiO_2 膜の形成により、周波数温度特性が改善されること
がわかる。特に、 SiO_2 膜の規格化された膜厚 HS/λ が0.25の近傍の場合、TCF
が0となり好ましいことがわかる。

【0100】

また、回転Y板X伝搬 LiTaO_3 基板として、カット角が 36° （オイラー角で $(0^\circ, 126^\circ, 0^\circ)$ ）及び 38° （オイラー角で $(0^\circ, 128^\circ, 0^\circ)$ ）の2種類の
オイラー角の LiTaO_3 基板を用い、AuからなるIDTの膜厚及び SiO_2 膜の膜厚
を種々変化させた場合の減衰定数 α の変化を数値解析した。結果を図20及び図21に示
す。なお、図20及び図21のAuの膜厚値は H/λ である。図20及び図21から明ら
かなように、AuからなるIDTの膜厚の如何に関わらず、 SiO_2 膜の膜厚を選択すれ
ば、減衰定数 α を小さくし得ることがわかる。すなわち、図20及び図21から明らかな
ように、 SiO_2 膜の膜厚 HS/λ を0.08~0.45、より好ましくは0.10~0.
35の範囲とすれば、いずれかのオイラー角の LiTaO_3 基板及びいずれの膜厚のAu
からなるIDTを形成した場合においても、減衰定数 α が非常に小さくされ得ることが
わかる。

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【0101】

さらに、図17により、AuからなるIDTを用いると、薄い膜厚でもAに比べて十分
大きな反射係数が得られていることがわかる。

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従って、上記図16~図21の結果から、 LiTaO_3 基板上に膜厚 H/λ が0.018
~0.030のAuからなるIDTを形成した場合、 SiO_2 膜の膜厚 HS/λ を0.0
3~0.45の範囲とすれば、大きな電気機械結合係数が得られるだけでなく、減衰定数
 α を非常に小さくし、かつ、十分な反射係数を得ることができることができる。

【0102】

上述した実施例において、カット角 36° （オイラー角で $(0^\circ, 126^\circ, 0^\circ)$ ）の
 LiTaO_3 基板上に、 $H/\lambda = 0.020$ の規格化膜厚のAuからなるIDTを形成し
、さらに規格化膜厚 $HS/\lambda = 0.1$ の SiO_2 膜を形成してなる実施例の弾性表面波装
置11の減衰量一周波数特性を図22に破線で示す。また、比較のために、該弾性表面波
フィルタにおいて、 SiO_2 膜を形成する前の構造の減衰量周波数特性を実線で示す。

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【0103】

図22から明らかなように、 SiO_2 膜の形成により電気機械結合係数が0.30から0.
28に若干小さくなるにもかかわらず、挿入損失が改善されていることがわかる。従っ
て、図22から明らかなように、 SiO_2 膜を上記特定の範囲の厚みとすれば、減衰定数
 α が小さくなることが裏付けられる。

【0104】

本願発明者は、上述した知見に基づき、様々なオイラー角の回転Y板X伝搬 LiTaO_3
基板上に、規格化膜厚が0.02であるAuからなるIDTを形成し、さらに様々な厚み
の SiO_2 膜を形成して1ポート型弾性表面波共振子を試作した。この場合、 SiO_2 膜
の規格化膜厚は、0.10、0.20、0.30及び0.45とした。このようにして得
られた各1ポート型弾性表面波共振子のQ値を測定した。結果を図26に示す。

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【0105】

一般に、共振子のQ値が大きい程、フィルタとして用いた場合の通過帯域から減衰域にか
けてのフィルタ特性の急峻性が高められる。従って、急峻なフィルタを必要とするとき
には、Q値は大きい方が望ましい。図26から明らかなように、 SiO_2 膜の膜厚の如何に
関わらず、カット角が 48° 回転Y板、オイラー角で $(0^\circ, 138^\circ, 0^\circ)$ 付近でQ
値が最大となり、カット角 $42^\circ \sim 58^\circ$ （オイラー角で $(0^\circ, 132^\circ \sim 148^\circ, 0^\circ)$ ）の範囲でQ値が比較的大きいことがわかる。

【0106】

従って、図26から明らかなように、カット角 $42^\circ \sim 58^\circ$ 回転Y板（オイラー角で（

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0° 、 $132^\circ \sim 148^\circ$ 、 0°))の LiTaO_3 基板を用い、該 LiTaO_3 基板上に、Auよりも密度の高い金属からなる少なくとも1つのIDTを形成し、さらに SiO_2 膜をIDTを覆うように LiTaO_3 基板上に形成した構造とすることにより、大きなQ値を得ることができることがわかる。好ましくは、図26から明らかなように、カット角は $46.5^\circ \sim 53^\circ$ 回転Y板(オイラー角 ϕ (0° 、 $136.5^\circ \sim 148^\circ$ 、 0°))とされる。

【0107】

なお、本発明においては、IDTの上面に密着層が形成されてもよい。すなわち、図27(a)に示すように、 LiTaO_3 基板82上に、IDT88が形成されており、IDT88の上面に、密着層84が作製されていてもよい。密着層84は、IDT88と SiO_2 膜85との間に配置されている。密着層84は、 SiO_2 膜85のIDT88に対する密着強度を高めるために設けられている。このような密着層84を構成する材料としては、PdまたはAl、あるいはこれらの合金が好適に用いられる。また、金属に限らず、 ZnO などの圧電材料や、 Ta_2O_5 もしくは Al_2O_3 などの他のセラミックスを用いて密着層84を構成してもよい。密着層84の形成により、Alよりも密度が高い金属からなるIDT88と SiO_2 膜85との密着強度が高められ、それによって SiO_2 膜の膜剥がれが抑制される。

【0108】

密着層84の厚みは、弾性表面波全般への影響を与えないためには、弾性表面波の波長の1%程度以下の厚みとすることが望ましい。また、図27(a)では、IDT88の上面に密着層84が形成されていたが、図27(b)に示すように、 LiTaO_3 基板上に SiO_2 膜85との界面にも密着層84Aを形成してもよい。さらに図27(c)に示すように、密着層84は、IDT88の上面だけでなく側面をも覆うように形成されてもよい。

【0109】

また、 SiO_2 膜の密着強度を改善する他の構成として、IDT以外のパスバーや外部との接続用パッドを含む複数の電極において、該複数の電極を、それぞれ、IDTと同じ材料からなる下地金属層と、下地金属層上に積層されており、AlもしくはAl合金からなる上層金属層からなるものを用いてもよい。すなわち、例えば図15に示した反射器24a、24bを構成する電極膜として、IDT23a、23bと同じ材料からなる下地金属層と、該下地金属層上に、Al膜を積層してもよい。このように、AlやAl合金からなる上層金属層を設けることにより、 SiO_2 膜との密着強度が高められる。また、電極コストを低減することもでき、さらにAlウェッジボンド性を高めることもできる。

【0110】

なお、上記IDT以外の電極としては、反射器、パスバー、外部との電極的接続用パッドだけでなく、必要に応じて形成される引き回し電極などが挙げられる。また、上記Al合金としては、特に限定されないが、Al-Ti合金、Al-Ni-Cr合金などが挙げられる。

【0111】

なお、上述した実験例の場合以外のオイラー角の回転Y板X伝搬 LiTaO_3 基板を用いた場合においても、AuからなるIDTを形成した場合において、減衰定数 α を最小とする SiO_2 膜の膜厚が存在することが本願発明者等により確かめられている。すなわち、 SiO_2 膜の膜厚 HS/λ を特定の範囲とすれば、上記実験例の場合と同様に、減衰定数 α を小さくすることができる。一方、 SiO_2 膜の膜厚 HS/λ を $0.1 \sim 0.45$ としたときのオイラー角と α の関係を図28～36に示す。これらの図から SiO_2 膜の膜厚が厚くなるに従い、 α が極小となるオイラー角の θ が小さくなることも明らかとなった。従って、他のオイラー角の回転Y板X伝搬 LiTaO_3 基板を用いた場合であっても、AuからなるIDTを形成し、 SiO_2 膜を積層した構造において、 SiO_2 膜の厚みを選択することにより、従来の弾性表面波装置に比べて、周波数温度特性TCFが半分以下と良好であり、電気機械結合係数が大きく、かつ反射係数が大きな弾性表面波装置を構成す

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ることができる。このような効果を発現し得る LiTaO_3 基板のオイラー角と、Au からなる IDT の電極膜厚と、 SiO_2 膜の膜厚の好ましい組み合わせは、以下の表 16 及び表 17 で示される通りであることが確かめられている。

【0112】

【表 16】

オイラー角 ($0 \pm 3^\circ$, θ , $0 \pm 3^\circ$) の θ	Au 膜厚	SiO_2 膜厚
$120.0^\circ \leq \theta < 123.0^\circ$	0.013~0.018	0.15~0.45
$123.0^\circ \leq \theta < 124.5^\circ$	0.013~0.022	0.10~0.40
$124.5^\circ \leq \theta < 125.5^\circ$	0.013~0.025	0.07~0.40
$125.5^\circ \leq \theta < 127.5^\circ$	0.013~0.025	0.06~0.40
$127.5^\circ \leq \theta < 129.0^\circ$	0.013~0.028	0.04~0.40
$129.0^\circ \leq \theta < 130.0^\circ$	0.017~0.030	0.03~0.42
$130.0^\circ \leq \theta < 131.5^\circ$	0.017~0.030	0.03~0.42
$131.5^\circ \leq \theta < 133.0^\circ$	0.018~0.028	0.05~0.33
$133.0^\circ \leq \theta < 135.0^\circ$	0.018~0.030	0.05~0.30
$135.0^\circ \leq \theta \leq 137.0^\circ$	0.019~0.032	0.05~0.25
$137.0^\circ \leq \theta \leq 140.0^\circ$	0.019~0.032	0.05~0.25

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【0113】

【表 17】

オイラー角 ($0 \pm 3^\circ$, θ , $0 \pm 3^\circ$) の θ	Au 膜厚	SiO_2 膜厚
$129.0^\circ \leq \theta < 130.0^\circ$	0.022~0.028	0.04~0.40
$130.0^\circ \leq \theta < 131.5^\circ$	0.022~0.028	0.04~0.40
$131.5^\circ \leq \theta < 133.0^\circ$	0.022~0.028	0.05~0.33
$133.0^\circ \leq \theta < 135.0^\circ$	0.022~0.030	0.05~0.30
$135.0^\circ \leq \theta < 137.0^\circ$	0.022~0.032	0.05~0.25
$137.0^\circ \leq \theta \leq 140.0^\circ$	0.022~0.032	0.05~0.25

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【0114】

なお、オイラー角の θ が所望の角度から $-2^\circ \sim +4^\circ$ ずれることがある。このずれは本願明細書における計算結果が基板の全面に金属膜を形成したものから計算されたものであるため、実際の弾性表面波装置では上記の範囲で誤差が発生することもある。

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【0115】

本発明に係る弾性表面波装置の製造に際しては、回転 Y 板 X 伝搬 LiTaO_3 基板上に Au を主成分とする金属からなる IDT を形成した後、その状態において周波数調整を行ない、しかる後減衰定数 α を小さくし得る範囲の膜厚の SiO_2 膜を成膜することが望ましい。これを、図 28 及び図 24 を参照して説明する。図 28 は、 86° 回転 Y 板 X 伝搬（オイラー角で $(0^\circ, 126^\circ, 0^\circ)$ ） LiTaO_3 基板上に、種々の膜厚の Au からなる IDT 及び種々の膜厚の SiO_2 膜を形成した場合の漏洩弾性表面波の音速の変化を示す。また、図 24 は、同じオイラー角の LiTaO_3 基板上に、種々の膜厚の Au からなる IDT を形成した場合、その上に形成される SiO_2 膜の規格化膜厚を変化させた場

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合の漏洩弾性表面波の音速の変化を示す。図23と図24を比較すれば明らかなように、Auの膜厚を変化させた場合の方が、 SiO_2 膜の膜厚を変化させた場合よりも弾性表面波の音速の変化はるかに大きい。従って、 SiO_2 膜の形成に先立ち、周波数調整が、行われることが望ましく、例えば、レーザーエッチングやイオンエッチングなどによりAuからなるIDTを形成した後に周波数調整を行うことが望ましい。特に好ましくは、Auの規格化膜厚が、0.015～0.03の範囲であれば、 SiO_2 膜による音速の変化が小さくなり、 SiO_2 膜のばらつきによる周波数変動を小さくすることができる。

【0116】

なお、オイラー角の θ が所望の角度から $-2^\circ \sim +4^\circ$ ずれることがある。このずれは本願明細書における計算結果が基板の全面に金属膜を形成したものから計算されたものであるため、実際の弾性表面波装置では上記の範囲で誤差が発生することもある。

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【0117】

また、製造の際、オイラー角の ϕ と ψ は 0° から $\pm 3^\circ$ ばらつくが、特性は 0° のものとはほぼ同じ特性が得られた。

〔電極材料がAuの実施例〕

本実施例の弾性表面波装置は、前述した図15に示した弾性表面波装置21と同様である。もっとも、本実施例では、IDT23a、23bがAuにより構成されている。

【0118】

後述するように、IDT23a、23bがAuからなる場合には、IDT23a、23bの弾性表面波の波長で規格化された膜厚 H/λ は0.01～0.08が好ましい。

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【0119】

本発明に係る弾性表面波装置では、上記のように、 LiTaO_3 基板22上にAuによりIDT23a、23bが構成されており、該IDT23a、23bの電極膜厚を薄くすることができる。オイラー角の LiTaO_3 基板を用いるため減衰定数を大幅に小さくすることができ、低ロス化が可能となる。また、 SiO_2 膜25の形成により、良好な周波数温度特性が実現される。これを、具体的な実験例に基づき説明する。

【0120】

LiTaO_3 基板を伝わる弾性表面波には、レイリー波の他に漏洩弾性表面波(LSAW)がある。漏洩弾性表面波は、レイリー波に比べて音速が早く、電気機械結合係数が大きい。エネルギーを基板内に放射しつつ伝搬する。従って、漏洩弾性表面波は、伝搬ロスの原因となる減衰定数を有する。

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【0121】

図36は、 36° 回転Y板X伝搬 LiTaO_3 基板(オイラー角で(0° , 126° , 0°))上に、AuからなるIDTを形成した場合のAu膜の規格化膜厚 H/λ と、電気機械結合係数 K_{SAW} との関係を示す。なお、 λ は、弾性表面波装置の中心周波数における波長を示すものとする。

【0122】

図36から明らかなように、Au膜の膜厚 H/λ が0.01～0.08の範囲において、電気機械結合係数 K_{SAW} が、Au膜が形成されていない場合($H/\lambda=0$)に比べて1.5倍以上となることがわかる。また、Au膜の膜厚が $H/\lambda=0.02 \sim 0.06$ の範囲では、Au膜が形成されていない場合に比べて、電気機械結合係数 K_{SAW} は1.7倍以上の値となり、Au膜の膜厚 H/λ が0.03～0.05の範囲では、Au膜が形成されていない場合の1.8倍以上の値となることがわかる。

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【0123】

Au膜の規格化膜厚 H/λ が0.08を超えると、Au膜からなるIDTの作製が困難となる。従って、大きな電気機械結合係数を得ることができ、かつIDTの作製が容易であるため、Au膜からなるIDTの厚みは、0.01～0.08の範囲であることが望ましく、より好ましくは0.02～0.06、さらに好ましくは0.03～0.05の範囲とされる。

【0124】

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次に、 LiTaO_3 基板上に、 SiO_2 膜を成膜した場合の周波数温度係数 TCF の変化を図 37 に示す。図 37 は、オイラー角 $(0^\circ, 118^\circ, 0^\circ)$ 、 $(0^\circ, 126^\circ, 0^\circ)$ 及び $(0^\circ, 129^\circ, 0^\circ)$ の 3 種類の LiTaO_3 基板上に SiO_2 膜が形成されている場合の SiO_2 膜の規格化膜厚 HS/λ と TCF との関係を示す。なお、ここでは電極は形成されていない。

【0125】

図 37 から明らかなように、 θ が 118° 、 126° 及び 129° のいずれの場合においても、 SiO_2 膜の規格化膜厚 HS/λ が $0.15 \sim 0.45$ の範囲において、 TCF が $-20 \sim +20 \text{ PPM}/^\circ\text{C}$ の範囲となることがわかる。もっとも、 SiO_2 膜の成膜には時間を要するため、 SiO_2 膜の膜厚 HS/λ は $0.15 \sim 0.40$ が望ましい。

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【0126】

LiTaO_3 基板上に SiO_2 膜を成膜することにより、レイリー波などの TCF が改善されることは知られていたが、 LiTaO_3 基板上に、 A 面からなる電極を形成し、さらに SiO_2 膜を積層した構造において、実際に、 A 面からなる電極の膜厚、 SiO_2 の膜厚、オイラー角、及び漏洩弾性波の減衰定数を考慮して実験された報告はない。

【0127】

図 38 は、オイラー角 $(0^\circ, 120^\circ, 0^\circ)$ の LiTaO_3 基板上に規格化膜厚 H/λ が 0.10 以下の A 面からなる電極と、規格化膜厚 HS/λ が $0 \sim 0.5$ の SiO_2 膜を形成した場合における減衰定数 α の変化を示す。図 38 から明らかなように、 SiO_2 膜の膜厚 HS/λ が $0.2 \sim 0.40$ 、 A 面膜の膜厚 H/λ が $0.01 \sim 0.10$ である場合に減衰定数 α が小さくなっていることがわかる。

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【0128】

他方、図 39 は、 $(0^\circ, 140^\circ, 0^\circ)$ のオイラー角の LiTaO_3 基板上には、規格化膜厚 H/λ が $0 \sim 0.10$ の A 面膜を形成し、さらに、規格化膜厚 HS/λ が $0 \sim 0.5$ の SiO_2 膜を形成した場合の減衰定数 α の変化を示す。

【0129】

図 39 から明らかなように、オイラー角で $\theta = 140^\circ$ の LiTaO_3 基板を用いた場合には、 A 面膜の膜厚が 0.06 以下において SiO_2 膜の膜厚を上記のように変化させてとしても、減衰定数 α は大きいことがわかる。

【0130】

すなわち、良好な TCF 、大きな電気機械結合係数及び小さな減衰定数を実現するには、 LiTaO_3 基板のカット角すなわちオイラー角と、 SiO_2 膜の膜厚と、 A 面からなる電極の膜厚とをそれぞれ最適なように組み合わせることが必要となることがわかる。

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【0131】

図 40～図 47 は、それぞれ、 SiO_2 膜の規格化膜厚 HS/λ が、 0.1 、 0.15 、 0.2 、 0.25 、 0.3 、 0.35 、 0.4 または 0.45 であり、規格化膜厚 H/λ が 0.1 以下の A 面膜を LiTaO_3 基板上に形成した場合の θ と減衰定数 α との関係を示す。

【0132】

図 40～図 47 から明らかなように、 A 面膜の厚み H/λ を $0.01 \sim 0.08$ とした場合、 SiO_2 膜の厚みと、オイラー角の θ とが、下記の表 18 に示すいずれかの組み合わせとなるように選択されれば、周波数温度特性 TCF が良好であり、電気機械結合係数が大きく、かつ減衰定数 α を効果的に抑制し得ることがわかる。望ましくは、下記の表 18 の右側のより好ましいオイラー角を選択することにより、より一層良好な特性を得ることができ。

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【0133】

【表 18】

Ag膜厚 H/λ : 0.01~0.08のとき

SiO ₂ 膜厚	LiTaO ₃ のオイラー角	より好ましいオイラー角
0.15~0.18	0±3, 117~137, 0±3	0±3, 120~135, 0±3
0.18~0.23	0±3, 117~136, 0±3	0±3, 118~133, 0±3
0.23~0.28	0±3, 115~135, 0±3	0±3, 117~133, 0±3
0.28~0.33	0±3, 113~133, 0±3	0±3, 115~132, 0±3
0.33~0.38	0±3, 113~135, 0±3	0±3, 115~133, 0±3
0.38~0.40	0±3, 113~132, 0±3	0±3, 115~130, 0±3

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【0184】

また、より好ましくは、Ag膜の規格化膜厚が0.02~0.06の場合には、SiO₂膜の厚みと、オイラー角の θ とが、下記の表19に示すいずれかの組み合わせとなるように選択されれば、より一層好ましく、さらに望ましくは、下記の表19の右側のより好ましいオイラー角を選択することにより、より一層良好な特性を得ることができる。

【0185】

【表19】

Ag膜厚 H/λ : 0.02~0.06のとき

SiO ₂ 膜厚	LiTaO ₃ のオイラー角	より好ましいオイラー角
0.15~0.18	0±3, 120~133, 0±3	0±3, 122~130, 0±3
0.18~0.23	0±3, 120~137, 0±3	0±3, 122~136, 0±3
0.23~0.28	0±3, 120~135, 0±3	0±3, 122~133, 0±3
0.28~0.33	0±3, 118~135, 0±3	0±3, 120~133, 0±3
0.33~0.38	0±3, 115~133, 0±3	0±3, 117~130, 0±3
0.38~0.40	0±3, 113~130, 0±3	0±3, 115~128, 0±3

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【0186】

さらに好ましくは、Ag膜の規格化膜厚が0.03~0.05のときに、SiO₂膜の厚みと、オイラー角の θ とが、下記の表20に示すいずれかの組み合わせとなるように選択されれば、より一層良好な特性を得ることができる。この場合においても、下記の表20の右側に示すより好ましいオイラー角を選択することにより、特性をより一層改善することができる。

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【0187】

【表20】

Ag膜厚 H/λ : 0.03~0.05のとき

SiO ₂ 膜厚	LiTaO ₃ のオイラー角	より好ましいオイラー角
0.15~0.18	0±3, 122~142, 0±3	0±3, 123~140, 0±3
0.18~0.23	0±3, 120~140, 0±3	0±3, 122~137, 0±3
0.23~0.28	0±3, 117~138, 0±3	0±3, 120~135, 0±3
0.28~0.33	0±3, 116~136, 0±3	0±3, 118~134, 0±3
0.33~0.38	0±3, 114~135, 0±3	0±3, 117~133, 0±3
0.38~0.40	0±3, 113~130, 0±3	0±3, 115~128, 0±3

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【0188】

なお、本発明では、IDTはAgのみから構成されてもよいが、Agを主体とする限り、Ag合金やAgと他の金属との積層体で構成されてもよい。Agを主体とするIDTとは、IDTの全体の80重量%以上がAgであればよい。従って、Agの下地にAl薄膜やTi薄膜が形成されていてもよく、この場合においても、下地の薄膜とAgとの合計のう

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ち80重量%以上がAlで構成されていればよい。

【0139】

上記実験では、オイラー角 $(0^\circ, \theta, 0^\circ)$ のLiTaO₃基板が用いられたが、基板材料のオイラー角において、 ϕ 及び ψ には $0 \pm 3^\circ$ のはらつきが通常発生する。このようなはらつきの範囲内、すなわち $(0 \pm 3^\circ, 113^\circ \sim 142^\circ, 0 \pm 3^\circ)$ のLiTaO₃基板においても、本発明の効果は得られる。

【0140】

なお、オイラー角の θ が所望の角度から $-2^\circ \sim +4^\circ$ ずれることがある。このずれは本願明細書における計算結果が基板の全面に金属膜を形成したのから計算されたものであるため、実際の弾性表面波装置では上記の範囲で誤差が発生することもある。

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【0141】

〔Cuを電極材料として用いた場合の実施例〕

Cuにより電極を形成したことを除いては、Alを用いた場合と同様に図15に示した弾性表面波装置を構成した。Alに比べて密度の高いCuにより電極が構成されているため、電気機械結合係数及び反射係数を高めることができる。

【0142】

図58は、SiO₂膜の規格化膜厚が0.20の場合のCu電極とAl電極の電極膜一本あたりの反射率と、電極膜厚との関係を示す図である。

図58に示すように、従来用いられているAlからなる電極に比べて、Cuからなる電極を用いた場合、電極指1本あたりの反射率が高められるため、反射器における電極指の本数も低減することができる。従って、反射器の小型化、ひいては弾性表面波装置の小型化を図ることができる。

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【0143】

後述するように、IDT23a、23bの弾性表面波の波長で規格化された膜厚 H/λ は0.01~0.08が好ましい。

図48は、オイラー角 $(0^\circ, 120^\circ, 0^\circ)$ のLiTaO₃基板上に規格化膜厚 H/λ が0.10以下のCuからなる電極と、規格化膜厚 HS/λ が0~0.5のSiO₂膜を形成した場合における減衰定数 α の変化を示す。図48から明らかなように、SiO₂膜の膜厚 HS/λ が0.2~0.40、Cu膜の膜厚 H/λ が0.01~0.10である場合に減衰定数 α が小さくなっていることがわかる。

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【0144】

他方、図49は、 $(0^\circ, 135^\circ, 0^\circ)$ のオイラー角のLiTaO₃基板上には、規格化膜厚 H/λ が0~0.10のCu膜を形成し、さらに、規格化膜厚 HS/λ が0~0.5のSiO₂膜を形成した場合の減衰定数 α の変化を示す。

【0145】

図49から明らかなように、 $\theta = 135^\circ$ のLiTaO₃基板を用いた場合には、Cu膜の膜厚及びSiO₂膜の膜厚を上記のように変化させたとしても、減衰定数 α は大きいことがわかる。

【0146】

すなわち、良好なTCF、大きな電気機械結合係数及び小さな減衰定数を実現するには、LiTaO₃基板のカット角すなわちオイラー角と、SiO₂膜の膜厚と、Cuからなる電極の膜厚とをそれぞれ最適なように組み合わせることが必要となることがわかる。

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【0147】

図50~図57は、それぞれ、SiO₂膜の規格化膜厚 HS/λ が、0.1、0.15、0.2、0.25、0.3、0.35、0.4または0.45であり、規格化膜厚 H/λ が0.08以下のCu膜をLiTaO₃基板上に形成した場合の θ と減衰定数 α との関係を示す。

【0148】

図50~図57から明らかなように、Cu膜の厚み H/λ を0.01~0.08とした場合、SiO₂膜の厚みと、オイラー角の θ とが、下記の表21に示すように選択されれば

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、周波数温度特性TCFが $\pm 20 \text{ P P m} / ^\circ\text{C}$ の範囲内とされて良好であり、電気機械結合係数が大きく、かつ減衰定数 α を効果的に抑制し得ることがわかる。望ましくは、下記の表21の右側のより好ましいオイラー角を選択することにより、より一層良好な特性を得ることができる。

【0149】

【表21】

SiO ₂ 膜厚	LiTaO ₃ のオイラー角	より好ましくは
0.15~0.18	($0 \pm 3, 117 \sim 137, 0 \pm 3$)	($0 \pm 3, 120 \sim 135, 0 \pm 3$)
0.18~0.23	($0 \pm 3, 117 \sim 136, 0 \pm 3$)	($0 \pm 3, 118 \sim 133, 0 \pm 3$)
0.23~0.28	($0 \pm 3, 115 \sim 135, 0 \pm 3$)	($0 \pm 3, 117 \sim 133, 0 \pm 3$)
0.28~0.33	($0 \pm 3, 113 \sim 133, 0 \pm 3$)	($0 \pm 3, 115 \sim 132, 0 \pm 3$)
0.33~0.38	($0 \pm 3, 113 \sim 135, 0 \pm 3$)	($0 \pm 3, 115 \sim 133, 0 \pm 3$)
0.38~0.4	($0 \pm 3, 113 \sim 132, 0 \pm 3$)	($0 \pm 3, 115 \sim 130, 0 \pm 3$)

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【0150】

また、Auについての図25から推測されるように、オイラー角の θ が 125° 以下になると、電気機械結合係数 K_{Saw} が著しく大きくなることから、従って、より好ましくは、下記の表22に示すSiO₂膜の規格化膜厚 HS/λ とオイラー角との組み合わせが望ましいことがわかる。

【0151】

【表22】

SiO ₂ 膜厚	LiTaO ₃ のオイラー角
0.15~0.18	($0 \pm 3, 117 \sim 125, 0 \pm 3$)
0.18~0.23	($0 \pm 3, 117 \sim 125, 0 \pm 3$)
0.23~0.28	($0 \pm 3, 115 \sim 125, 0 \pm 3$)
0.28~0.33	($0 \pm 3, 113 \sim 125, 0 \pm 3$)
0.33~0.38	($0 \pm 3, 113 \sim 125, 0 \pm 3$)
0.38~0.40	($0 \pm 3, 113 \sim 125, 0 \pm 3$)

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【0152】

さらに、図48~図56に示した結果から、減衰定数が0もしくは最小となるオイラー角、すなわち θ_{min} を、SiO₂膜の規格化膜厚 HS/λ 及びCu膜の規格化膜厚 H/λ に対して求めた結果を、図59に示す。

【0153】

Cu膜の規格化膜厚 H/λ が、0、0.02、0.04、0.06及び0.08の場合の図59に示す各曲線を三次式で近似することにより、下記の式A~Eが得られる。

(a) $0 < H/\lambda \leq 0.01$ のとき

$$\theta_{\text{min}} = -189.713 \times HS^3 + 48.07182 \times HS^2 - 20.568011 \times HS + 125.8314 \quad \text{式A}$$

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(b) $0.01 < H/\lambda \leq 0.03$ のとき

$$\theta_{\text{min}} = -189.660 \times HS^3 + 46.02985 \times HS^2 - 21.141500 \times HS + 127.4181 \quad \text{式B}$$

(c) $0.03 < H/\lambda \leq 0.05$ のとき

$$\theta_{\text{min}} = -189.607 \times HS^3 + 48.98838 \times HS^2 - 21.714900 \times HS + 129.0048 \quad \text{式C}$$

(d) $0.05 < H/\lambda \leq 0.07$ のとき

$$\theta_{\text{min}} = -112.068 \times HS^3 + 39.60355 \times HS^2 - 21.186000 \times HS + 129.9397 \quad \text{式D}$$

(e) $0.07 < H/\lambda \leq 0.09$ のとき

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$$\theta_{\min} = -126.954 \times HS^3 + 67.40488 \times HS^2 - 29.482000 \times HS + 131.5686 \quad \text{式E}$$

従って、好ましくは、オイラー角 ($0 \pm 3^\circ$, θ , $0 \pm 3^\circ$) の θ は、上述した式A～式Eで示される θ_{\min} とされることが望ましいが、 $\theta_{\min} - 2^\circ < \theta \leq \theta_{\min} + 2^\circ$ であれば、減衰定数を効果的に小さくすることができる。

【0154】

なお、本発明ではIDTはCuのみから構成されてもよいが、Cuを主体とする限り、Cu合金やCuと他の金属との積層体で構成されてもよい。Cuを主体とするIDTとは、電極の平均密度を ρ (平均) とすると

$$\rho(\text{Cu}) \times 0.7 \leq \rho(\text{平均}) \leq \rho(\text{Cu}) \times 1.3$$

すなわち、

$$6.259 / \text{cm}^3 \leq \rho(\text{平均}) \leq 11.69 / \text{cm}^3$$

を満足するものであればよい。なお、Cuの上あるいは下に電極全体の ρ (平均) が上記範囲となるように、Alよりも密度の大きいW、Ta、Au、Pt、AgまたはCrなどの金属からなる電極を積層してもよい。その場合にも、Cu電極単層の場合と同様の効果が得られる。

【0155】

なお、オイラー角の θ が所望の角度から $-2^\circ \sim +4^\circ$ ずれることがある。このずれは本願明細書における計算結果が基板の全面に金属膜を形成したのから計算されたものであるため、実際の弾性表面波装置では上記の範囲で誤差が発生することもある。

【0156】

また、製造の際、オイラー角の ϕ と ψ は 0° から $\pm 3^\circ$ はらつくが、特性は 0° のものとはほぼ同じ特性が得られた。

【電極材料としてタングステンを用いた実施例】

前述した実施例と同様に、図15に示した弾性表面波装置を構成した。但し、IDT及び反射器をタングステンにより構成した。IDTの規格化膜厚 H/λ は $0.0025 \sim 0.06$ の範囲とした。

【0157】

また、LiTaO₃ 基板としては、 $22^\circ \sim 48^\circ$ 回転Y板X伝搬、オイラー角で (0° , $112^\circ \sim 188^\circ$, 0°) のLiTaO₃ 基板を用いた。

本実施例では上記のように、 $22^\circ \sim 48^\circ$ 回転Y板X伝搬LiTaO₃ からなる圧電基板22と、 $H/\lambda = 0.0025 \sim 0.06$ であるタングステンよりなるIDT8a, 8bと、 $HS/\lambda = 0.10 \sim 0.40$ の範囲にあるSiO₂ 膜4とを用いているため、周波数温度係数TCFが小さく、電気機械結合係数 K_{sa_w} が大きく、かつ伝搬損失が小さい弾性表面波装置を提供することができる。これを、以下の具体的な実験例に基づき説明する。

【0158】

図60及び図61は、オイラー角 (0° , 120° , 0°) と、(0° , 140° , 0°) の各LiTaO₃ 基板上に、種々の膜厚のタングステンからなるIDTと、種々の膜厚のSiO₂ 膜とを形成した場合の減衰定数を示す図である。

【0159】

図60から明らかなように、 $\theta = 120^\circ$ では、SiO₂ の膜厚 HS/λ が $0.1 \sim 0.40$ かつタングステンよりなる電極の規格化膜厚 H/λ が $0.0 \sim 0.10$ の範囲において、減衰定数が小さいことがわかる。他方、図61から明らかなように、 $\theta = 140^\circ$ では、タングステンからなる電極の規格化膜厚 H/λ が $0.0 \sim 0.10$ の範囲では、SiO₂ 膜の膜厚の如何に係わらず、減衰定数が大きくなっていることがわかる。

【0160】

すなわち、TCFを $\pm 20 \text{ PPM}/^\circ\text{C}$ と小さくし、大きな電気機械結合係数を得、かつ減衰定数を小さくするには、LiTaO₃ 基板のオイラー角、SiO₂ 膜の厚み及びタングステンからなる電極の膜厚の3つの条件を考慮しなければならないことがわかる。

【0161】

図62～図65は、 SiO_2 膜の規格化膜厚 H/λ 及びタングステンからなる電極膜の規格化膜厚 H/λ を変化させた場合の、 θ （度）と減衰定数との関係を示す。

【0162】

図62～図65から明らかなように、タングステンからなる電極の規格化膜厚 H/λ が0.012～0.053及び0.015～0.042において、 SiO_2 膜の膜厚と、最適な θ との関係は、下記の表23及び表24に示す通りとなる。なお、この最適 θ は、タングステン電極の電極指幅のばらつきや単結晶基板のばらつきにより $-2^\circ \sim +4^\circ$ 程度ばらつくことがある。なお、図中、図示していない膜厚は比例配分による。

【0163】

【表23】

電極の $H/\lambda = 0.012 \sim 0.053$ のとき

SiO_2 の規格化膜厚	LiTaO_3 のオイラー角	より好ましくは
0.1～0.15	$(0 \pm 3, 114.2 \sim 138, 0 \pm 3)$	$(0 \pm 3, 117.7 \sim 134, 0 \pm 3)$
0.15～0.2	$(0 \pm 3, 113 \sim 137.8, 0 \pm 3)$	$(0 \pm 3, 117 \sim 133.5, 0 \pm 3)$
0.2～0.3	$(0 \pm 3, 113 \sim 137.5, 0 \pm 3)$	$(0 \pm 3, 116.5 \sim 133, 0 \pm 3)$
0.3～0.35	$(0 \pm 3, 112.7 \sim 137, 0 \pm 3)$	$(0 \pm 3, 116.5 \sim 133, 0 \pm 3)$
0.35～0.4	$(0 \pm 3, 112.5 \sim 136, 0 \pm 3)$	$(0 \pm 3, 116.5 \sim 132.3, 0 \pm 3)$

【0164】

【表24】

電極の $H/\lambda = 0.015 \sim 0.042$ のとき

SiO_2 の規格化膜厚	LiTaO_3 のオイラー角	より好ましくは
0.1～0.15	$(0 \pm 3, 114.3 \sim 138, 0 \pm 3)$	$(0 \pm 3, 117.7 \sim 133.5, 0 \pm 3)$
0.15～0.2	$(0 \pm 3, 113 \sim 137.5, 0 \pm 3)$	$(0 \pm 3, 117.7 \sim 133.5, 0 \pm 3)$
0.2～0.3	$(0 \pm 3, 112.5 \sim 137, 0 \pm 3)$	$(0 \pm 3, 117 \sim 132.5, 0 \pm 3)$
0.3～0.35	$(0 \pm 3, 112.2 \sim 136.5, 0 \pm 3)$	$(0 \pm 3, 116.8 \sim 132.5, 0 \pm 3)$
0.35～0.4	$(0 \pm 3, 112 \sim 135.3, 0 \pm 3)$	$(0 \pm 3, 116 \sim 131.5, 0 \pm 3)$

【0165】

すなわち、表23及び表24から明らかなように、タングステンよりなる電極の膜厚 H/λ が、0.012～0.053の場合、周波数温度特性TCFを $\pm 20 \text{ PPM}/^\circ\text{C}$ の範囲内となるように改善するために、 SiO_2 膜の膜厚 H/λ を0.1～0.4の範囲とした場合、 LiTaO_3 のオイラー角における θ は、 $112^\circ \sim 138^\circ$ の範囲、すなわち、回転角で $20^\circ \sim 50^\circ$ の範囲、より好ましくは、表23に示すオイラー角を選択すればよいことがわかる。

【0166】

同様に、表24から明らかなように、タングステン膜からなる電極の規格化膜厚が0.015～0.042であり、周波数温度特性TCFを $\pm 20 \text{ PPM}/^\circ\text{C}$ の範囲内となるように改善するために、 SiO_2 膜の膜厚 H/λ を0.1～0.4の範囲とした場合には、 LiTaO_3 基板のオイラー角は $112^\circ \sim 138^\circ$ の範囲とすればよく、より好ましくは SiO_2 膜の膜厚に応じて表24のオイラー角を選択すればよいことがわかる。

【0167】

ここで、表23及び表24における「 LiTaO_3 のオイラー角」の範囲は、減衰定数が0.05以下の範囲を規定したものである。また、表23及び表24における LiTaO_3 のオイラー角の「より好ましい」範囲は、減衰定数が0.025以下に規定したものである。また、タングステンからなる電極膜の規格化膜厚が0.012、0.015、0.042、0.053である場合の SiO_2 膜の膜厚 H/λ とオイラー角の関係は、図62～図65に示すタングステンからなる電極膜の規格化膜厚から換算して求めたものであ

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り、それによって、表 23 及び表 24 の SiO_2 膜の膜厚とオイラー角の値を求めている。

【0168】

本発明に係る弾性表面波装置の製造に際しては、回転 Y 板 X 伝搬 LiTaO_3 基板上にタングステン主成分とする金属からなる IDT を形成した後、その状態において周波数調整を行い、しかる後減衰定数 α を小さくし得る範囲の膜厚の SiO_2 膜を成膜することが望ましい。これを、図 66 及び図 67 を参照して説明する。図 66 は、オイラー角 (0° , 126° , 0°) の回転 Y 板 X 伝搬 LiTaO_3 基板上に、種々の厚み H/λ のタングステンからなる IDT 及び種々の膜厚 HS/λ の SiO_2 膜を形成した場合の漏洩弾性表面波の音速の変化を示す。また、図 67 は、同じオイラー角の LiTaO_3 基板上に、種々の膜厚 H/λ のタングステンからなる IDT を形成した場合、その上に形成される SiO_2 膜の規格化膜厚 HS/λ を変化させた場合の漏洩弾性表面波の音速の変化を示す。図 66 と図 67 を比較すれば明らかなように、タングステンの膜厚を変化させた場合の方が、 SiO_2 膜の膜厚を変化させた場合よりも弾性表面波の音速の変化がはるかに大きい。従って、 SiO_2 膜の形成に先立ち、周波数調整が、行われることが望ましく、例えば、レーザーエッチングやイオンエッチングなどによりタングステン (W) からなる IDT を形成した後、周波数調整を行うことが望ましい。

【0169】

なお、本発明は、上記のように、 $22^\circ \sim 48^\circ$ 回転 Y 板 X 伝搬、オイラー角で (0° , $112^\circ \sim 188^\circ$, 0°) の LiTaO_3 からなる圧電基板、 $H/\lambda = 0.0025 \sim 0.06$ であるタングステンよりなる IDT と、 $HS/\lambda = 0.10 \sim 0.40$ である SiO_2 膜とを有することを特徴とするものであり、従って、IDT の数及び構造等については特に限定されない。すなわち、本発明は、図 15 に示した弾性表面波装置だけでなく、上記条件を満たす限り、様々な弾性表面波共振子や弾性表面波フィルタ等に適用することができる。

【0170】

なお、オイラー角の θ が所望の角度から $-2^\circ \sim +4^\circ$ ずれることがある。このずれは本願明細書における計算結果が基板の全面に金属膜を形成したもののから計算されたものであるため、実際の弾性表面波装置では上記の範囲で誤差が発生することもある。

また、製造の際、オイラー角の ϕ と ψ は 0° から $\pm 3^\circ$ ばらつくが、特性は 0° のものとはほぼ同じ特性が得られた。

【0171】

〔電極材料として Ta を用いた場合の実施例〕

図 15 に示した弾性表面波装置を構成した。但し、 $14^\circ \sim 58^\circ$ 回転 Y 板 X 伝搬、オイラー角で (0° , $104^\circ \sim 148^\circ$, 0°) の LiTaO_3 からなる基板を圧電性基板 22 として用い、かつ IDT はタンタル (Ta) により構成し、その規格化膜厚 H/λ は $0.004 \sim 0.055$ の範囲とした。

【0172】

本実施例では上記のように、 $14^\circ \sim 58^\circ$ 回転 Y 板 X 伝搬、オイラー角で (0° , $104^\circ \sim 148^\circ$, 0°) の LiTaO_3 からなる圧電基板 2 と、 $H/\lambda = 0.004 \sim 0.055$ であるタンタルよりなる IDT 3a, 3b と、 $HS/\lambda = 0.10 \sim 0.40$ の範囲にある SiO_2 膜 4 とを用いているため、周波数温度係数 TCF が小さく、電気機械結合係数 K_{saw} が大きく、かつ伝搬損失が小さい弾性表面波装置を提供することができる。これを、以下の具体的な実験例に基づき説明する。

【0173】

図 68 及び図 69 は、オイラー角 (0° , 120° , 0°) と、(0° , 140° , 0°) の各 LiTaO_3 基板上に、種々の膜厚のタンタルからなる IDT と、種々の膜厚の SiO_2 膜とを形成した場合の減衰定数を示す図である。

【0174】

図 68 から明らかなように、 $\theta = 120^\circ$ では、 SiO_2 の膜厚 HS/λ が $0.1 \sim 0.$

40 かつタンタルよりなる電極の規格化膜厚 H/λ が 0.0～0.10 の範囲において、減衰定数が小さいことがわかる。他方、図 69 から明らかなように、 $\theta = 140^\circ$ では、タンタルからなる電極の規格化膜厚 H/λ が 0.0～0.06 の範囲では、 SiO_2 膜の膜厚の如何に係わらず、減衰定数が大きくなっていることがわかる。

【0175】

すなわち、TCF の絶対値を小さくし、大きな電気機械結合係数を得、かつ減衰定数を小さくするには、 LiTaO_3 基板のオイラー角、 SiO_2 膜の厚み及びタンタルからなる電極の膜厚の 3 つの条件を考慮しなければならないことがわかる。

【0176】

図 70～図 73 は、 SiO_2 膜の規格化膜厚 HS/λ 及びタンタルからなる電極膜の規格化膜厚 H/λ を変化させた場合の、 θ と減衰定数との関係を示す。

図 70～図 73 から明らかなように、タンタルからなる電極の規格化膜厚 H/λ が 0.01～0.055 及び 0.016～0.045 において、 SiO_2 膜の膜厚と、最適な θ との関係は、下記の表 25 及び表 26 に示す通りとなる。なお、この最適 θ は、タンタル電極の電極指幅のばらつきや単結晶基板のばらつきにより $-2^\circ \sim +4^\circ$ 程度ばらつくことがある。

【0177】

【表 25】

電極の $H/\lambda = 0.01 \sim 0.055$ のとき

SiO_2 の規格化膜厚	LiTaO_3 のオイラー角	より好ましくは
0.1～0.15	($0 \pm 3, 110.5 \sim 148, 0 \pm 3$)	($0 \pm 3, 116 \sim 143, 0 \pm 3$)
0.15～0.2	($0 \pm 3, 108 \sim 147.5, 0 \pm 3$)	($0 \pm 3, 115 \sim 141.5, 0 \pm 3$)
0.2～0.3	($0 \pm 3, 105 \sim 148, 0 \pm 3$)	($0 \pm 3, 111 \sim 139, 0 \pm 3$)
0.3～0.35	($0 \pm 3, 104.5 \sim 148, 0 \pm 3$)	($0 \pm 3, 111 \sim 139, 0 \pm 3$)
0.35～0.4	($0 \pm 3, 104 \sim 145, 0 \pm 3$)	($0 \pm 3, 110 \sim 138.5, 0 \pm 3$)

【0178】

【表 26】

電極の $H/\lambda = 0.016 \sim 0.045$ のとき

SiO_2 の規格化膜厚	LiTaO_3 のオイラー角	より好ましくは
0.1～0.15	($0 \pm 3, 113 \sim 144, 0 \pm 3$)	($0 \pm 3, 118 \sim 140, 0 \pm 3$)
0.15～0.2	($0 \pm 3, 111 \sim 144, 0 \pm 3$)	($0 \pm 3, 117 \sim 139.5, 0 \pm 3$)
0.2～0.3	($0 \pm 3, 108 \sim 144, 0 \pm 3$)	($0 \pm 3, 113 \sim 139, 0 \pm 3$)
0.3～0.35	($0 \pm 3, 107.5 \sim 143, 0 \pm 3$)	($0 \pm 3, 112.5 \sim 137, 0 \pm 3$)
0.35～0.4	($0 \pm 3, 107 \sim 140.5, 0 \pm 3$)	($0 \pm 3, 112 \sim 135.5, 0 \pm 3$)

【0179】

すなわち、表 25 及び表 26 から明らかなように、タンタルよりなる電極の膜厚 H/λ が、0.01～0.055 の場合、周波数温度特性 TCF を $\pm 20 \text{ PPM}/^\circ\text{C}$ の範囲内とするように改善するために、 SiO_2 膜の規格化膜厚を 0.1～0.4 の範囲とした場合、 LiTaO_3 のオイラー角における θ は、 $104^\circ \sim 148^\circ$ の範囲、すなわち、回転角で $14^\circ \sim 58^\circ$ の範囲、より好ましくは、 SiO_2 の膜厚 HS/λ に応じて表 25 に示すオイラー角を選択すればよいことがわかる。

【0180】

同様に、表 26 から明らかなように、タンタル膜からなる電極の規格化膜厚が 0.016～0.045 であり、周波数温度特性 TCF を改善するために、 SiO_2 膜の膜厚 HS/λ

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入を0.1～0.4の範囲とした場合には、 LiTaO_3 基板のオイラー角は $107^\circ \sim 144^\circ$ の範囲とすればよく、より好ましくは SiO_2 膜の膜厚 HS/λ に応じて表26のオイラー角を選択すればよいことがわかる。

【0181】

LiTaO_3 のオイラー角の範囲は、減衰定数が0.05以下の範囲を規定したものである。また、表25及び表26における LiTaO_3 のオイラー角のより好ましい範囲は、減衰定数が0.025以下に規定したものである。また、タンタルからなる電極膜の規格化膜厚が0.012、0.015、0.042、0.058である場合の SiO_2 膜の膜厚 HS/λ とオイラー角の関係は、図70～図73に示すタンタルからなる電極膜の規格化膜厚から換算して求めて、表25及び表26の SiO_2 膜の膜厚 HS/λ とオイラー角

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【0182】

本発明に係る弾性表面波装置の製造に際しては、回転Y板X伝搬 LiTaO_3 基板上にタンタルを主成分とする金属からなるIDTを形成した後、その状態において周波数調整を行い、しかる後減衰定数 α を小さくし得る範囲の膜厚の SiO_2 膜を成膜することが望ましい。これを、図74及び図75を参照して説明する。図74は、オイラー角(0° 、 126° 、 0°)の回転Y板X伝搬 LiTaO_3 基板上に、タンタルからなるIDT及び SiO_2 膜を形成した場合の、タンタルの規格化膜厚 H/λ と、 SiO_2 膜の規格化膜厚 HS/λ と、漏洩弾性表面波の音速との関係を示す。また、図75は、同じオイラー角の LiTaO_3 基板上に、種々の膜厚のタンタルからなるIDTを形成し、その上に形成される SiO_2 膜の規格化膜厚を変化させた場合の漏洩弾性表面波の音速の変化を示す。図74と図75を比較すれば明らかなように、タンタルの膜厚を変化させた場合の方が、 SiO_2 膜の膜厚を変化させた場合よりも弾性表面波の音速の変化がはるかに大きい。従って、 SiO_2 膜の形成に先立ち、周波数調整が、行われることが望ましく、例えば、レーザーエッチングやイオンエッチングなどによりタンタルからなるIDTを形成した後に周波数調整を行うことが望ましい。

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【0183】

なお、本発明は、上記のように、 $14^\circ \sim 58^\circ$ 回転Y板X伝搬、オイラー角 ϕ (0° 、 $104^\circ \sim 148^\circ$ 、 0°)の LiTaO_3 からなる圧電基板、 $H/\lambda = 0.004 \sim 0.055$ であるタンタルよりなるIDTと、 $HS/\lambda = 0.10 \sim 0.40$ である SiO_2 膜とを有することを特徴とするものであり、従って、IDTの数及び構造等については特に限定されない。すなわち、本発明は、図15に示した弾性表面波装置だけでなく、上記条件を満たす限り、様々な弾性表面波共振子や弾性表面波フィルタ等に適用することができる。

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【0184】

なお、オイラー角の θ が所望の角度から $-2^\circ \sim +4^\circ$ ずれることがある。このずれは本願明細書における計算結果が基板の全面に金属膜を形成したもののから計算されたものであるため、実際の弾性表面波装置では上記の範囲で誤差が発生することもある。また、製造の際、オイラー角の ϕ と ψ は 0° から $\pm 3^\circ$ ばらつくが、特性は 0° のものとはほぼ同じ特性が得られた。

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【0185】

〔電極材料として白金を用いた実施例〕

図15に示した弾性表面波装置を、 $0^\circ \sim 79^\circ$ 回転Y板X伝搬、オイラー角 ϕ (0° 、 $90^\circ \sim 169^\circ$ 、 0°)の LiTaO_3 基板からなる圧電基板と、 $H/\lambda = 0.005 \sim 0.054$ である白金よりなるIDTを用いて構成した。その他の点は前述した実施例と同様である。

【0186】

本実施例においても、上記構成を備えるため、周波数温度係数TCFが小さく、電気機械結合係数 K_{saw} が大きく、かつ伝搬損失が小さい弾性表面波装置を提供することができる。これを、以下の具体的な実験例に基づき説明する。

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【0187】

図76及び図77は、オイラー角(0° , 125° , 0°)と、(0° , 140° , 0°)の各LiTaO₃基板上に、種々の膜厚の白金からなるIDTと、種々の膜厚のSiO₂膜とを形成した場合の減衰定数を示す図である。

【0188】

図76から明らかなように、 $\theta = 125^\circ$ では、SiO₂の膜厚 H_s/λ が0.1~0.40かつ白金よりなる電極の規格化膜厚 H/λ が0.005~0.06の範囲において、減衰定数が小さいことがわかる。他方、図77から明らかなように、 $\theta = 140^\circ$ では、白金からなる電極の規格化膜厚 H/λ が0.005~0.06の範囲では、SiO₂膜の膜厚 H_s/λ の如何に係わらず、減衰定数が大きくなっていることがわかる。

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【0189】

すなわち、TCFの絶対値を小さくし、大きな電気機械結合係数を得、かつ減衰定数を小さくするには、LiTaO₃基板のオイラー角、SiO₂膜の厚み及び白金からなる電極の膜厚の3つの条件を考慮しなければならないことがわかる。

【0190】

図78~図88は、SiO₂膜の規格化膜厚 H_s/λ 及び白金からなる電極膜の規格化膜厚 H/λ を変化させた場合の、オイラー角の θ (度)と減衰定数との関係を示す。

【0191】

図78~図88から明らかなように、白金からなる電極の規格化膜厚 H/λ が0.005~0.054では、 θ は $90^\circ \sim 169^\circ$ の範囲とすることが望ましいことがわかる。また、白金からなる電極の規格化膜厚 H/λ が0.01~0.04及び0.018~0.033においては、SiO₂膜の膜厚 H_s/λ と、最適な θ との関係は、減衰定数 α を低下させることも考慮すると、下記の表27及び表28に示す通りとなる。ここで、表27及び表28における「LiTaO₃のオイラー角」の範囲は、減衰定数が0.05dB/ λ 以下の範囲を規定したものである。また、表27及び表28におけるLiTaO₃のオイラー角の「より好ましい」範囲は、減衰定数が0.025dB/ λ 以下の範囲を規定したものである。なお、この最適 θ は、白金電極の電極指幅のばらつきや単結晶基板のばらつきにより $-2^\circ \sim +4^\circ$ 程度はらつくことがある。

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【0192】

また、製造の際、オイラー角の ϕ と ψ は 0° から $\pm 3^\circ$ はらつくが、特性は 0° のものとはほぼ同じ特性が得られた。

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【0193】

【表27】

白金 $H/\lambda = 0.01 \sim 0.04$ のとき

SiO ₂ 厚(H_s/λ)	オイラー角	より好ましいオイラー角
$0.1 \leq H_s/\lambda < 0.15$	($0 \pm 3^\circ$, $90^\circ \sim 169^\circ$, $0 \pm 3^\circ$)	($0 \pm 3^\circ$, $105^\circ \sim 153^\circ$, $0 \pm 3^\circ$)
$0.15 \leq H_s/\lambda < 0.2$	($0 \pm 3^\circ$, $90^\circ \sim 167^\circ$, $0 \pm 3^\circ$)	($0 \pm 3^\circ$, $105^\circ \sim 152^\circ$, $0 \pm 3^\circ$)
$0.20 \leq H_s/\lambda < 0.25$	($0 \pm 3^\circ$, $90^\circ \sim 167^\circ$, $0 \pm 3^\circ$)	($0 \pm 3^\circ$, $107^\circ \sim 152^\circ$, $0 \pm 3^\circ$)
$0.25 \leq H_s/\lambda < 0.3$	($0 \pm 3^\circ$, $90^\circ \sim 164^\circ$, $0 \pm 3^\circ$)	($0 \pm 3^\circ$, $104^\circ \sim 151^\circ$, $0 \pm 3^\circ$)
$0.3 \leq H_s/\lambda < 0.4$	($0 \pm 3^\circ$, $90^\circ \sim 163^\circ$, $0 \pm 3^\circ$)	($0 \pm 3^\circ$, $105^\circ \sim 150^\circ$, $0 \pm 3^\circ$)

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【0194】

【表28】

白金 $H/\lambda = 0.013 \sim 0.033$ のとき

SiO_2 厚 (H_s/λ)	オイラー角	より好ましいオイラー角
$0.1 \leq H_s/\lambda < 0.15$	$(0 \pm 3^\circ, 106^\circ \sim 155^\circ, 0 \pm 3^\circ)$	$(0 \pm 3^\circ, 116^\circ \sim 147.5^\circ, 0 \pm 3^\circ)$
$0.15 \leq H_s/\lambda < 0.2$	$(0 \pm 3^\circ, 104^\circ \sim 155^\circ, 0 \pm 3^\circ)$	$(0 \pm 3^\circ, 113.5^\circ \sim 150^\circ, 0 \pm 3^\circ)$
$0.20 \leq H_s/\lambda < 0.25$	$(0 \pm 3^\circ, 102^\circ \sim 155^\circ, 0 \pm 3^\circ)$	$(0 \pm 3^\circ, 111.5^\circ \sim 150^\circ, 0 \pm 3^\circ)$
$0.25 \leq H_s/\lambda < 0.3$	$(0 \pm 3^\circ, 102^\circ \sim 154^\circ, 0 \pm 3^\circ)$	$(0 \pm 3^\circ, 112^\circ \sim 146^\circ, 0 \pm 3^\circ)$
$0.3 \leq H_s/\lambda < 0.4$	$(0 \pm 3^\circ, 102^\circ \sim 153^\circ, 0 \pm 3^\circ)$	$(0 \pm 3^\circ, 110^\circ \sim 144.5^\circ, 0 \pm 3^\circ)$

【0195】

すなわち、表 27 及び表 28 から明らかなように、白金よりなる電極の膜厚 H/λ が、0.01～0.04 の場合、周波数温度特性 TCF を $\pm 20 \text{ PPM}/^\circ\text{C}$ の範囲内となるように改善するために、 SiO_2 膜の膜厚 H_s/λ を 0.1～0.4 の範囲とした場合、 LiTaO_3 のオイラー角における θ は、 $90^\circ \sim 169^\circ$ の範囲、すなわち、回転角で $0^\circ \sim 79^\circ$ の範囲を選択すればよいことがわかる。

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【0196】

同様に、表 27 から明らかなように、白金膜からなる電極の規格化膜厚が 0.01～0.04 であり、周波数温度特性 TCF を $\pm 20 \text{ PPM}/^\circ\text{C}$ の範囲内となるように改善するために、 SiO_2 膜の膜厚 H_s/λ を 0.1～0.4 の範囲とした場合には、 LiTaO_3 基板のオイラー角の θ は $90^\circ \sim 169^\circ$ の範囲とすればよく、より好ましくは SiO_2 膜の膜厚に応じて表 27 のオイラー角を選択すればよいことがわかる。

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【0197】

同様に、白金膜からなる電極の規格化膜厚が 0.013～0.033 であり、周波数温度特性 TCF を $\pm 20 \text{ PPM}/^\circ\text{C}$ の範囲となるように改善するために、 SiO_2 膜の膜厚 H_s/λ を 0.1～0.4 の範囲とした場合には、 LiTaO_3 基板のオイラー角の θ は、 $102^\circ \sim 150^\circ$ の範囲とすればよく、より好ましくは、 SiO_2 膜の膜厚 H_s/λ に応じて表 28 のオイラー角を選択すればよいことがわかる。

【0198】

また、白金からなる電極膜の規格化膜厚が 0.013～0.033 である場合の SiO_2 膜の膜厚とオイラー角の関係は、図 78～図 83 に示す白金からなる電極膜の規格化膜厚から換算して求めたものであり、それによって、表 27 及び表 28 の SiO_2 膜の膜厚 H_s/λ とオイラー角の値を求めている。

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【0199】

本発明に係る弾性表面波装置の製造に際しては、回転 Y 板 X 伝搬 LiTaO_3 基板上に白金を主成分とする金属からなる IDT を形成した後、その状態において周波数調整を行い、しかる後減衰定数 α を小さくし得る範囲の膜厚 H_s/λ の SiO_2 膜を成膜することが望ましい。これを、図 84 及び図 85 を参照して説明する。図 84 は、オイラー角 ($0^\circ, 126^\circ, 0^\circ$) の回転 Y 板 X 伝搬 LiTaO_3 基板上に、種々の厚み H/λ の白金からなる IDT 及び種々の膜厚 H_s/λ の SiO_2 膜を形成した場合の漏洩弾性表面波の音速の変化を示す。また、図 85 は、同じオイラー角の LiTaO_3 基板上に、種々の膜厚 H/λ の白金からなる IDT を形成した場合、その上に形成される SiO_2 膜の規格化膜厚 H_s/λ を変化させた場合の漏洩弾性表面波の音速の変化を示す。図 84 と図 85 を比較すれば明らかなように、白金の膜厚を変化させた場合の方が、 SiO_2 膜の膜厚を変化させた場合よりも弾性表面波の音速の変化がはるかに大きい。従って、 SiO_2 膜の形成に先立ち、周波数調整が行われることが望ましく、例えば、レーザーエッチングやイオンエッチングなどにより白金からなる IDT を形成した後、周波数調整を行うことが望ましい。

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【0200】

なお、本発明は、上記のように、 $0^\circ \sim 79^\circ$ 回転 Y 板 X 伝搬、オイラー角で ($0^\circ, 90^\circ \sim 169^\circ, 0^\circ$) の LiTaO_3 からなる圧電基板、 $H/\lambda = 0.005 \sim 0.054$ である白金よりなる IDT と、 $H_s/\lambda = 0.10 \sim 0.40$ である SiO_2 膜とを

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有することを特徴とするものであり、従って、IDTの数及び構造等については特に限定されない。すなわち、本発明は、図1に示した弾性表面波装置だけでなく、上記条件を満たす限り、様々な弾性表面波共振子や弾性表面波フィルタ等に適用することができる。

【0201】

〔ニッケル及びモリブデンを電極材料として用いた実施例〕

図15に示した弾性表面波装置を構成した。電極材料としてニッケルまたはモリブデンを用いた。また、圧電性基板として、 $14^\circ \sim 50^\circ$ 回転Y板X伝搬、オイラー角で $(0^\circ, 104^\circ \sim 140^\circ, 0^\circ)$ のLiTaO₃基板を用いた。その他の点は同様である。

【0202】

IDT23a、23b及び反射器25a、25bは、密度が $8700 \sim 10300 \text{ kg/m}^3$ 、ヤング率が $1.8 \times 10^{11} \sim 4 \times 10^{11} \text{ N/m}^2$ 及び横波音速が $3170 \sim 3290 \text{ m/秒}$ である金属により構成されている。このような金属としては、ニッケルやモリブデンまたはこれらを主体とする合金が挙げられる。

【0203】

IDT23a、23bの規格化膜厚 H/λ （ H はIDTの厚み、 λ は中心周波数における波長を示す）は $0.008 \sim 0.06$ の範囲とされている。

本実施例では上記のように、 $14^\circ \sim 50^\circ$ 回転Y板X伝搬、オイラー角で $(0^\circ, 104^\circ \sim 140^\circ, 0^\circ)$ のLiTaO₃からなる圧電基板22と、 $H/\lambda = 0.008 \sim 0.06$ であり、上記特定の金属よりなるIDT23a、23bと、 $HS/\lambda = 0.10 \sim 0.40$ の範囲にあるSiO₂膜24とを用いているため、周波数温度係数TCFが $\pm 20 \text{ ppm/}^\circ\text{C}$ の範囲内となるように小さくされており、電気機械結合係数 K_{saew} が大きく、かつ伝搬損失が小さい弾性表面波装置を提供することができる。これを、以下の具体的な実験例に基づき説明する。

【0204】

図86及び図87は、オイラー角 $(0^\circ, 120^\circ, 0^\circ)$ と、 $(0^\circ, 140^\circ, 0^\circ)$ の各LiTaO₃基板上に、種々の膜厚のNiからなるIDTと、種々の膜厚 HS/λ のSiO₂膜とを形成した場合の減衰定数を示す図である。

【0205】

図86から明らかなように、 $\theta = 120^\circ$ では、SiO₂の膜厚 HS/λ が $0.1 \sim 0.40$ かつNiよりなる電極の規格化膜厚 H/λ が $0.008 \sim 0.08$ の範囲において、減衰定数が小さいことがわかる。他方、図87から明らかなように、 $\theta = 140^\circ$ では、Niからなる電極の規格化膜厚 H/λ が $0.008 \sim 0.08$ の範囲では、SiO₂膜の膜厚の如何に係わらず、減衰定数が大きくなっていることがわかる。

【0206】

図88及び図89は、オイラー角 $(0^\circ, 120^\circ, 0^\circ)$ と $(0^\circ, 140^\circ, 0^\circ)$ の各LiTaO₃基板上に、種々の膜厚のMoからなるIDTと、種々の膜厚 HS/λ のSiO₂膜とを形成した場合の減衰定数の変化を示す図である。

【0207】

図88から明らかなように、 $\theta = 120^\circ$ では、SiO₂の膜厚 HS/λ が $0.1 \sim 0.40$ かつMoよりなる電極の規格化膜厚 H/λ が $0.008 \sim 0.08$ の範囲において、減衰定数が小さいことがわかる。他方、図89から明らかなように、 $\theta = 140^\circ$ では、Moからなる電極の規格化膜厚 H/λ が $0.008 \sim 0.08$ の範囲では、SiO₂膜の膜厚 HS/λ の如何に係わらず、減衰定数が大きくなっていることがわかる。

【0208】

すなわち、TCFの絶対値を小さくし、大きな電気機械結合係数を得、かつ減衰定数を小さくするには、LiTaO₃基板のオイラー角、SiO₂膜の厚み HS/λ 及び上記特定の密度、ヤング率及び横波音速範囲の金属からなる電極の膜厚の3つの条件を考慮しなければならないことがわかる。

【0209】

図90～図98は、SiO₂膜の規格化膜厚 HS/λ 及びNiからなる電極膜の規格化膜

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厚 H/λ を変化させた場合の、 θ （度）と減衰定数との関係を示す。

図94～図97は、 SiO_2 膜の規格化膜厚 HS/λ 及び MO からなる電極膜の規格化膜厚 H/λ を変化させた場合の、 θ （度）と減衰定数との関係を示す。

【0210】

図90～図97から明らかなように、 Ni または MO からなる電極の規格化膜厚 H/λ が0.008～0.06、0.017～0.06及び0.023～0.06において、 SiO_2 膜の膜厚と、最適な θ との関係は、下記の表29に示す通りとなる。なお、この最適 θ は、電極の電極指幅のばらつきや単結晶基板のばらつきにより $-2^\circ \sim +4^\circ$ 程度ばらつくことがある。

【0211】

また、製造の際、オイラー角の ϕ と ψ は 0° から $\pm 3^\circ$ ばらつくが、特性は 0° のものとはほぼ同じ特性が得られた。

【0212】

【表29】

SiO_2	オイラー角	より好ましいオイラー角
0.1～0.2	$(0 \pm 3^\circ, 105^\circ \sim 140^\circ, 0 \pm 3^\circ)$	$(0 \pm 3^\circ, 110^\circ \sim 135^\circ, 0 \pm 3^\circ)$
0.2～0.3	$(0 \pm 3^\circ, 105^\circ \sim 140^\circ, 0 \pm 3^\circ)$	$(0 \pm 3^\circ, 108^\circ \sim 135^\circ, 0 \pm 3^\circ)$
0.3～0.4	$(0 \pm 3^\circ, 104^\circ \sim 139^\circ, 0 \pm 3^\circ)$	$(0 \pm 3^\circ, 108^\circ \sim 133^\circ, 0 \pm 3^\circ)$

【0213】

また、図90～図93で示した Ni からなる電極の最適膜厚 $H/\lambda = 0.008 \sim 0.06$ 、 $0.02 \sim 0.06$ 及び $0.027 \sim 0.06$ における SiO_2 膜の膜厚と最適 θ との関係は下記の表30に示す通りとなる。

【0214】

【表30】

SiO_2	オイラー角	より好ましいオイラー角
0.1～0.2	$(0 \pm 3^\circ, 106^\circ \sim 140^\circ, 0 \pm 3^\circ)$	$(0 \pm 3^\circ, 110^\circ \sim 135^\circ, 0 \pm 3^\circ)$
0.2～0.3	$(0 \pm 3^\circ, 105^\circ \sim 137^\circ, 0 \pm 3^\circ)$	$(0 \pm 3^\circ, 108^\circ \sim 134^\circ, 0 \pm 3^\circ)$
0.3～0.4	$(0 \pm 3^\circ, 104^\circ \sim 133^\circ, 0 \pm 3^\circ)$	$(0 \pm 3^\circ, 108^\circ \sim 132^\circ, 0 \pm 3^\circ)$

【0215】

また、図94～図97に示した MO からなる電極の最適膜厚 $H/\lambda = 0.008 \sim 0.06$ 、 $0.017 \sim 0.06$ 及び $0.023 \sim 0.06$ における SiO_2 膜の膜厚と、最適な θ との関係は下記の表31に示す通りとなる。

【0216】

【表31】

SiO_2	オイラー角	より好ましいオイラー角
0.1～0.2	$(0 \pm 3^\circ, 107^\circ \sim 141^\circ, 0 \pm 3^\circ)$	$(0 \pm 3^\circ, 110^\circ \sim 135^\circ, 0 \pm 3^\circ)$
0.2～0.3	$(0 \pm 3^\circ, 104^\circ \sim 141^\circ, 0 \pm 3^\circ)$	$(0 \pm 3^\circ, 109^\circ \sim 135^\circ, 0 \pm 3^\circ)$
0.3～0.4	$(0 \pm 3^\circ, 104^\circ \sim 138^\circ, 0 \pm 3^\circ)$	$(0 \pm 3^\circ, 108^\circ \sim 133^\circ, 0 \pm 3^\circ)$

【0217】

すなわち、表29から明らかなように、上記特定の密度、ヤング率及び横波音速範囲の金属からなる電極の膜厚 H/λ が、0.008～0.06、0.017～0.06及び0.023～0.06で、周波数温度特性TCFを $\pm 20 \text{ PPM}/^\circ\text{C}$ の範囲内となるように改善するために、 SiO_2 膜の膜厚を0.1～0.4の範囲とした場合、 LiTaO_3 のオイラー角における θ は、 $104^\circ \sim 140^\circ$ の範囲、すなわち、回転角 ϕ は $14^\circ \sim 50^\circ$

の範囲、より好ましくは、表 29 に示すオイラー角を選択すればよいことがわかる。

【0218】

同様に、Ni 膜からなる電極の規格化膜厚 H/λ が 0.008 ~ 0.06、0.02 ~ 0.06 及び 0.027 ~ 0.06 の場合において、周波数温度特性 TCF を $\pm 20 \text{ PPM}/^\circ\text{C}$ の範囲内となるように改善するために、 HS/λ が 0.1 ~ 0.4 の SiO_2 膜の膜厚 HS/λ に応じて、 LiTaO_3 基板のオイラー角における θ は $104^\circ \sim 140^\circ$ の範囲とすればよく、より好ましくは SiO_2 膜の膜厚 HS/λ に応じて表 30 に示したオイラー角を選択すればよいことがわかる。

【0219】

同様に、Mo 膜からなる電極の規格化膜厚 H/λ が 0.008 ~ 0.06、0.02 ~ 0.06 及び 0.027 ~ 0.06 の場合において、周波数温度特性 TCF を $\pm 20 \text{ PPM}/^\circ\text{C}$ の範囲内となるように改善するために、 HS/λ が 0.1 ~ 0.4 の SiO_2 膜の膜厚 HS/λ に応じて、 LiTaO_3 基板のオイラー角における θ は $104^\circ \sim 141^\circ$ の範囲とすればよく、より好ましくは SiO_2 膜の膜厚 HS/λ に応じて表 31 に示したオイラー角を選択すればよいことがわかる。

【0220】

ここで、表 29 ~ 表 31 における「 LiTaO_3 のオイラー角」の範囲は、減衰定数 α が $0.1 \text{ dB}/\lambda$ 以下の範囲を規定したものである。また、表 29 ~ 表 31 における LiTaO_3 のオイラー角の「より好ましい」範囲は、減衰定数が $0.05 \text{ dB}/\lambda$ 以下の範囲を規定したものである。また、上記電極膜の規格化膜厚が 0.095、0.017、0.028 である場合の SiO_2 膜の膜厚 HS/λ とオイラー角の関係は、図 90 ~ 図 97 に示す Ni もしくは Mo からなる電極膜の規格化膜厚から換算して求めたものであり、それによって、表 29 ~ 表 31 の SiO_2 膜の膜厚とオイラー角の値を求めている。

【0221】

本発明に係る弾性表面波装置の製造に際しては、回転 Y 板 X 伝搬 LiTaO_3 基板上に Ni や Mo などの上記特定の金属からなる IDT を形成した後、その状態において周波数調整を行い、しかる後減衰定数 α を小さくし得る範囲の膜厚の SiO_2 膜を成膜することが望ましい。これを、図 98 ~ 図 101 を参照して説明する。図 98 及び図 100 は、オイラー角 (0° , 126° , 0°) の回転 Y 板 X 伝搬 LiTaO_3 基板上に、種々の厚み H/λ の Ni または Mo からなる IDT 及び種々の膜厚 HS/λ の SiO_2 膜を形成した場合の漏洩弾性表面波の音速の変化を示す。また、図 99 及び図 101 は、同じオイラー角の LiTaO_3 基板上に、種々の膜厚 H/λ の Ni または Mo からなる IDT を形成した場合、その上に形成される SiO_2 膜の規格化膜厚 HS/λ を変化させた場合の漏洩弾性表面波の音速の変化を示す。図 98 と図 99、及び図 100 と図 101 とを比較すれば明らかのように、電極の膜厚を変化させた場合の方が、 SiO_2 膜の膜厚を変化させた場合よりも弾性表面波の音速の変化がはるかに大きい。従って、 SiO_2 膜の形成に先立ち、周波数調整が、行われることが望ましく、例えば、レーザーエッチングやイオンエッチングなどにより Ni や Mo からなる IDT を形成した後に周波数調整を行うことが望ましい。

【0222】

なお、本発明は、上記のように、 $14^\circ \sim 50^\circ$ 回転 Y 板 X 伝搬、オイラー角で (0° , $104^\circ \sim 140^\circ$, 0°) の LiTaO_3 からなる圧電基板、 $H/\lambda = 0.008 \sim 0.06$ である Ni や Mo などの上記特定の密度、ヤング率及び横波音速範囲の金属よりなる IDT と、 $HS/\lambda = 0.10 \sim 0.40$ である SiO_2 膜とを有することを特徴とするものであり、従って、IDT の数及び構造等については特に限定されない。すなわち、本発明は、図 15 に示した弾性表面波装置だけでなく、上記条件を満たす限り、様々な弾性表面波共振子や弾性表面波フィルタ等に適用することができる。

【0223】

【発明の効果】

第 1 の発明に係る弾性表面波装置では、IDT 電極が形成されている領域を除いた残りの

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領域において、IDT電極と略等しい膜厚に形成された第1の絶縁物層が設けられており、IDT電極及び第1絶縁物層を被覆するように第2絶縁物層が設けられている構成において、IDT電極が第1絶縁物層の密度よりも高密度の金属または該金属を主成分とする合金からなるため、IDT電極の反射係数を十分な大きさとすることができ、従って、所望でないリップルによる特性の劣化が生じ難い、周波数温度特性の良好な弾性表面波装置を提供することができる。

【0224】

加えて、IDT電極と第1絶縁物層が略等しい膜厚とされており、IDT電極及び第1絶縁物層を被覆するように第2絶縁物層が積層されているため、第2絶縁物層の外表面を平坦化することができ、それによって第2絶縁物層表面の凹凸による特性の劣化も生じ難い

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【0225】

第2の発明に係る弾性表面波装置では、IDT電極が形成されている領域を除いた残りの領域にIDT電極とほぼ等しい膜厚の第1絶縁物層が設けられており、IDT電極上に、IDT電極を構成する金属もしくは合金よりも耐腐食性に優れた金属もしくは合金からなる保護金属膜が設けられており、保護金属膜及び第1絶縁物層上を被覆するように第2絶縁物層が形成されている。従って、IDT電極が保護金属層及び第1絶縁物層により覆われているため、フォトリソグラフィ技術によりレジストを剥離する際のレジスト剥離液によるIDT電極の腐食が生じ難い。よって、Cuなどのレジスト剥離液により腐食され易いが、密度がAlに比べて十分大きな金属もしくは合金を用いて、IDT電極を構成することができ、弾性表面波装置の特性の劣化を効果的に抑制することができる。

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【0226】

第1、第2の発明において、第1、第2の絶縁物層がSiO₂により構成されている場合には、本発明に従って、周波数温度特性TCFが改善された弾性表面波装置を提供することができる。

【0227】

IDT電極がCuまたはCuを主成分とする合金からなる場合には、従来から弾性表面波装置の電極材料として汎用されてきたAlに比べて密度が大きいので、第1、第2の発明に従った弾性表面波装置を容易に構成することができ、かつ十分な反射係数のIDT電極を容易に形成することができる。

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【0228】

第3の発明に係る製造方法では、圧電性基板2に第1絶縁物層を形成した後に、レジストパターンを用いてIDT電極が形成される部分の絶縁物層が除去され、残りの領域に第1絶縁物層とレジストとの積層構造が残留され、次に、第1絶縁物層が除去されている領域にAlよりも高密度の金属または該金属を主成分とする電極膜を形成することによりIDT電極が形成され、しかる後、第1絶縁物層上に残留しているレジストが除去される。そして、第1絶縁物層及びIDT電極上を被覆するように第2絶縁物層が形成されるため、第2絶縁物層上面の凹凸が生じ難い。従って、第2の絶縁物層表面の凹凸による特性の劣化が生じ難い。加えて、IDT電極がAlよりも高密度の金属または該金属を主成分とする合金からなるため、IDT電極の反射係数が高められ、所望でないリップルによる特性の劣化を抑制することができる。

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【0229】

また、第4の発明によれば、IDT電極を形成した後に、IDT電極を構成する金属もしくは合金よりも耐腐食性に優れた金属もしくは合金からなる保護金属膜が形成され、しかる後、第1絶縁物層上のレジスト及び該レジスト上に積層されている保護金属膜が除去される。従って、レジスト剥離液によりこの除去工程を行うに際し、IDT電極の側面が第1絶縁物層により、上面が保護金属層により覆われているため、IDT電極の腐食が生じ難い。

【0230】

従って、IDT電極の腐食を引き起こすことなく、第2の発明に係る弾性表面波装置を提

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供することが可能となる。

第5の発明によれば、圧電基板上に電極を形成し、該電極を覆うように絶縁物層を形成した後、電極が存在する部分と存在しない部分の上方における絶縁物層の表面の凹凸が平坦化される。従って、第1の発明と同様に、絶縁物層表面の凹凸による特性の劣化が生じ難い。

【図面の簡単な説明】

【図1】(a)～(g)は、本発明の一実施例における弾性表面波装置の製造方法を説明するための各模式的部分切欠断面図。

【図2】オイラー角(0°、126°、0°)のLiTaO₃基板上に、種々の膜厚でAl、AuまたはPtからなるIDT電極を形成し、さらに規格化膜厚HS/λが0.2のSiO₂膜を形成してなる1ポート型弾性表面波共振子において、SiO₂膜の表面を平坦化した場合と平坦化していない場合の電極膜厚と反射係数との関係を示す図。

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【図3】オイラー角(0°、126°、0°)のLiTaO₃基板上に、種々の膜厚でAl、CuまたはAgからなるIDT電極を形成し、さらに規格化膜厚HS/λが0.2のSiO₂膜を形成してなる1ポート型弾性表面波共振子において、SiO₂膜の表面を平坦化した場合と平坦化していない場合の電極膜厚と反射係数との関係を示す図。

【図4】比較例の製造方法で得られた弾性表面波共振子のSiO₂膜の規格化膜厚と、位相特性及びインピーダンス特性との関係を示す図。

【図5】比較のために用意した弾性表面波共振子におけるSiO₂膜の膜厚と、共振子のMFとの関係を示す図。

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【図6】本発明の一実施例で得られた1ポート型弾性表面波共振子の模式的平面図。

【図7】実施例の製造方法において、SiO₂膜の規格化膜厚を変化させた場合のインピーダンス特性及び位相特性の変化を示す図。

【図8】実施例及び比較例の製造方法により得られた弾性表面波共振子におけるSiO₂膜の膜厚と共振子のγとの関係を示す図。

【図9】実施例及び比較例の製造方法により得られた弾性表面波共振子におけるSiO₂膜の膜厚と共振子のMFとの関係を示す図。

【図10】実施例及び比較例で用意された弾性表面波共振子におけるSiO₂膜の厚みと、周波数温度特性TCFの変化との関係を示す図。

【図11】第2の比較例で用意されたSiO₂膜が形成された弾性表面波共振子と、SiO₂膜を有しないインピーダンス一周波数特性を示す図。

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【図12】(a)～(e)は、IDT電極及び保護金属膜の平均密度の第1絶縁物層の密度に対する比を変化させた場合のインピーダンス特性の変化を示す図。

【図13】オイラー角(0°、126°、0°)のLiTaO₃基板上に様々な金属からなるIDT電極を様々な厚みで形成した場合の電気機械結合係数の変化を示す図。

【図14】LiTaO₃基板上に様々な金属によりIDT電極を形成した場合に、Alからなる電極を用いた場合に比べて電気機械結合係数が大きくなる電極膜厚範囲と電極材料との密度との関係を示す図。

【図15】本発明の他の実施例に係る弾性表面波装置を示す斜視図。

【図16】36°回転Y板X伝搬(オイラー角で(0°、126°、0°))のLiTaO₃基板上に、Au、Ta、Ag、Cr、W、Cu、Zn、Mo、NiからなるIDT及びAlからなるIDTを形成した場合のIDTの規格化された電極膜厚と電気機械結合係数との関係を示す図。

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【図17】36°回転Y板X伝搬(オイラー角で(0°、126°、0°))のLiTaO₃基板上に各種電極材料からなるIDTの電極指片方の反射係数と膜厚の関係を示す図。

【図18】36°回転Y板X伝搬(オイラー角で(0°、126°、0°))のLiTaO₃基板上に、Au、Ta、Ag、Cr、W、Cu、Zn、Mo、NiからなるIDT及びAlからなるIDTを形成した場合の、IDTの電極規格化膜厚と減衰定数との関係を示す図。

【図19】36°回転Y板X伝搬(オイラー角で(0°、126°、0°))のLiTaO₃

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図 3 基板上に、規格化膜厚が 0.02 である Au からなる IDT を形成し、種々の膜厚の SiO_2 膜を形成した場合の周波数温度特性 (TCF) の変化を示す図。

【図 20】 36° 回転 Y 板 X 伝搬 (オイラー角 ϕ ($0^\circ, 126^\circ, 0^\circ$)) の LiTaO₃ 基板上に、種々の厚みの Au からなる IDT を形成し、さらに上に積層される SiO_2 膜規格化膜厚を変化させた場合の減衰定数 α の変化を示す図。

【図 21】 38° 回転 Y 板 X 伝搬 (オイラー角 ϕ ($0^\circ, 128^\circ, 0^\circ$)) の LiTaO₃ 基板上に、種々の厚みの Au からなる IDT を形成し、さらに上に積層される SiO_2 膜規格化膜厚を変化させた場合の減衰定数 α の変化を示す図。

【図 22】実施例の弾性表面波装置の減衰量周波数特性及び SiO_2 膜成膜前の比較のための弾性表面波装置の減衰量周波数特性を示す図。

【図 23】 36° 回転 Y 板 X 伝搬 (オイラー角 ϕ ($0^\circ, 126^\circ, 0^\circ$)) の LiTaO₃ 基板上に、Au からなる IDT を形成し、種々の膜厚の SiO_2 膜を形成した構造において、Au からなる IDT の規格化膜厚を変化させた場合の漏洩弾性表面波の音速の変化を示す図。

【図 24】 36° 回転 Y 板 X 伝搬 (オイラー角 ϕ ($0^\circ, 126^\circ, 0^\circ$)) の LiTaO₃ 基板上に、種々の規格化膜厚の Au からなる IDT を形成し、さらに SiO_2 膜積層とした構造において、 SiO_2 膜の規格化膜厚を変化させた場合の漏洩弾性表面波の音速の変化を示す図。

【図 25】オイラー角 ϕ ($0^\circ, \theta, 0^\circ$) の θ 、Au からなる IDT の規格化膜厚及び SiO_2 膜の規格化膜厚を変化させた場合の電気機械結合係数の変化を示す図。

【図 26】LiTaO₃ 基板のオイラー角の θ 及び SiO_2 膜の規格化膜厚を変化させた場合の共振子の Q 値の変化を示す図。

【図 27】(a) ~ (c) は、密着層が設けられた本発明の変形例に係る弾性表面波装置を説明するための各模式的断面図。

【図 28】 SiO_2 膜の膜厚 $H/\lambda = 0.1$ における各種 Au 電極膜厚における減衰定数 α と θ の関係を示す図。

【図 29】 SiO_2 膜の膜厚 $H/\lambda = 0.15$ における各種 Au 電極膜厚における減衰定数 α と θ の関係を示す図。

【図 30】 SiO_2 膜の膜厚 $H/\lambda = 0.2$ における各種 Au 電極膜厚における減衰定数 α と θ の関係を示す図。

【図 31】 SiO_2 膜の膜厚 $H/\lambda = 0.25$ における各種 Au 電極膜厚における減衰定数 α と θ の関係を示す図。

【図 32】 SiO_2 膜の膜厚 $H/\lambda = 0.3$ における各種 Au 電極膜厚における減衰定数 α と θ の関係を示す図。

【図 33】 SiO_2 膜の膜厚 $H/\lambda = 0.35$ における各種 Au 電極膜厚における減衰定数 α と θ の関係を示す図。

【図 34】 SiO_2 膜の膜厚 $H/\lambda = 0.4$ における各種 Au 電極膜厚における減衰定数 α と θ の関係を示す図。

【図 35】 SiO_2 膜の膜厚 $H/\lambda = 0.45$ における各種 Au 電極膜厚における減衰定数 α と θ の関係を示す図。

【図 36】オイラー角 ($0^\circ, 126^\circ, 0^\circ$) の LiTaO₃ 基板上に、種々の膜厚の A₉ 膜からなる電極を形成した場合の A₉ 膜の規格化膜厚 H/λ と、電気機械結合係数 $K_{\text{sa w}}$ との関係を示す図。

【図 37】オイラー角 ($0^\circ, 118^\circ, 0^\circ$)、($0^\circ, 126^\circ, 0^\circ$) 及び ($0^\circ, 129^\circ, 0^\circ$) の 3 種類の LiTaO₃ 基板において、電極膜厚が 0 で、種々の膜厚の SiO_2 膜を成膜した場合の SiO_2 膜の規格化膜厚 H_s/λ と周波数温度係数 TCF との関係を示す図。

【図 38】オイラー角 ($0^\circ, 120^\circ, 0^\circ$) の LiTaO₃ 基板上に、0.1 以下の規格化膜厚の A₉ 膜を形成し、0 ~ 0.5 の規格化膜厚の SiO_2 膜を成膜した場合の減衰定数 α の変化を示す図。

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【図55】オイラー角 (0° , θ , 0°) の LiTaO_3 基板上に、規格化膜厚 H/λ が 0.1 以下の各種 Cu 膜を形成し、規格化膜厚 H_S/λ が 0.35 の SiO_2 膜を積層し

た場合の、減衰定数 α の変化を示す図。

【図56】オイラー角 $(0^\circ, \theta, 0^\circ)$ の LiTaO_3 基板上に、規格化膜厚 H/λ が 0.1 以下の各種 Cu 膜を形成し、規格化膜厚 HS/λ が 0.4 の SiO_2 膜を積層した場合の、減衰定数 α の変化を示す図。

【図57】オイラー角 $(0^\circ, \theta, 0^\circ)$ の LiTaO_3 基板上に、規格化膜厚 H/λ が 0.1 以下の各種 Cu 膜を形成し、規格化膜厚 HS/λ が 0.45 の SiO_2 膜を積層した場合の、減衰定数 α の変化を示す図。

【図58】 SiO_2 膜の規格化膜厚が 0.02 のときの Al からなる電極及び Cu からなる電極における電極指 1 本当りの反射率と電極膜厚との関係を示す図。

【図59】減衰定数が 0 もしくは最小となる θ_{\min} を実現するための SiO_2 膜の規格化膜厚 HS/λ と、 Cu 膜の規格化膜厚 H/λ との関係を示す図。

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【図60】オイラー角 $(0^\circ, 120^\circ, 0^\circ)$ の LiTaO_3 基板上に、様々な厚みの SiO_2 膜及び様々な厚みのタングステンからなる IDT を形成した構造における減衰定数 α の変化を示す図。

【図61】オイラー角 $(0^\circ, 140^\circ, 0^\circ)$ の LiTaO_3 基板上に、様々な厚みの SiO_2 膜及び様々な厚みのタングステンからなる IDT を形成した構造における減衰定数 α の変化を示す図。

【図62】オイラー角 $(0^\circ, \theta, 0^\circ)$ の LiTaO_3 基板上に、様々な厚みのタングステンよりなる電極膜を形成し、さらに規格化膜厚 $HS/\lambda = 0.1$ の SiO_2 膜を形成した弾性表面波装置における θ と、タングステンよりなる電極膜の規格化厚み H/λ と、減衰定数 α との関係を示す図。

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【図63】オイラー角 $(0^\circ, \theta, 0^\circ)$ の LiTaO_3 基板上に、様々な厚みのタングステンよりなる電極膜を形成し、さらに規格化膜厚 $HS/\lambda = 0.2$ の SiO_2 膜を形成した弾性表面波装置における θ と、タングステンよりなる電極膜の規格化厚み H/λ と、減衰定数 α との関係を示す図。

【図64】オイラー角 $(0^\circ, \theta, 0^\circ)$ の LiTaO_3 基板上に、様々な厚みのタングステンよりなる電極膜を形成し、さらに規格化膜厚 $HS/\lambda = 0.3$ の SiO_2 膜を形成した弾性表面波装置における θ と、タングステンよりなる電極膜の規格化厚み H/λ と、減衰定数 α との関係を示す図。

【図65】オイラー角 $(0^\circ, \theta, 0^\circ)$ の LiTaO_3 基板上に、様々な厚みのタングステンよりなる電極膜を形成し、さらに規格化膜厚 $HS/\lambda = 0.4$ の SiO_2 膜を形成した弾性表面波装置における θ と、タングステンよりなる電極膜の規格化厚み H/λ と、減衰定数 α との関係を示す図。

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【図66】オイラー角 $(0^\circ, 126^\circ, 0^\circ)$ の LiTaO_3 基板上にタングステンからなる IDT を形成し、さらに SiO_2 膜を形成した場合のタングステン膜の膜厚と、 SiO_2 膜の膜厚と、音速との関係を示す図。

【図67】オイラー角 $(0^\circ, 126^\circ, 0^\circ)$ の LiTaO_3 基板上にタングステンからなる IDT を形成し、さらに SiO_2 膜を形成した場合のタングステン膜の膜厚と、 SiO_2 膜の膜厚と、音速との関係を示す図。

【図68】オイラー角 $(0^\circ, 120^\circ, 0^\circ)$ の LiTaO_3 基板上に、様々な厚みの SiO_2 膜及び様々な厚みのタンタルからなる IDT を形成した構造における減衰定数 α の変化を示す図。

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【図69】オイラー角 $(0^\circ, 140^\circ, 0^\circ)$ の LiTaO_3 基板上に、様々な厚みの SiO_2 膜及び様々な厚みのタンタルからなる IDT を形成した構造における減衰定数 α の変化を示す図。

【図70】オイラー角 $(0^\circ, \theta, 0^\circ)$ の LiTaO_3 基板上に、様々な厚みのタンタルよりなる電極膜を形成し、さらに規格化膜厚 $HS/\lambda = 0.1$ の SiO_2 膜を形成した弾性表面波装置における θ と、タンタルよりなる電極膜の規格化厚み H/λ と、減衰定数 α との関係を示す図。

【図71】オイラー角 $(0^\circ, \theta, 0^\circ)$ の LiTaO_3 基板上に、様々な厚みのタンタ

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ルよりなる電極膜を形成し、さらに規格化膜厚 $HS/\lambda = 0.2$ の SiO_2 膜を形成した弾性表面波装置における θ と、タンタルよりなる電極膜の規格化厚み H/λ と、減衰定数 α との関係を示す図。

【図72】オイラー角 $(0^\circ, \theta, 0^\circ)$ の $LiTaO_3$ 基板上に、様々な厚みのタンタルよりなる電極膜を形成し、さらに規格化膜厚 $HS/\lambda = 0.3$ の SiO_2 膜を形成した弾性表面波装置における θ と、タンタルよりなる電極膜の規格化厚み H/λ と、減衰定数 α との関係を示す図。

【図73】オイラー角 $(0^\circ, \theta, 0^\circ)$ の $LiTaO_3$ 基板上に、様々な厚みのタンタルよりなる電極膜を形成し、さらに規格化膜厚 $HS/\lambda = 0.4$ の SiO_2 膜を形成した弾性表面波装置における θ と、タンタルよりなる電極膜の規格化厚み H/λ と、減衰定数 α との関係を示す図。

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【図74】オイラー角 $(0^\circ, 126^\circ, 0^\circ)$ の $LiTaO_3$ 基板上にタンタルからなるIDTを形成し、その上に SiO_2 膜を形成した構造における、タンタルの規格化膜厚と、 SiO_2 の規格化膜厚と、音速との関係を示す図。

【図75】オイラー角 $(0^\circ, 126^\circ, 0^\circ)$ の $LiTaO_3$ 基板上にタンタルからなるIDTが形成されており、その上に SiO_2 膜が形成された構造における、タンタルの規格化膜厚と、 SiO_2 の規格化膜厚と、音速との関係を示す図。

【図76】オイラー角 $(0^\circ, 125^\circ, 0^\circ)$ の $LiTaO_3$ 基板上に、様々な厚みの SiO_2 膜及び様々な厚みの白金からなるIDTを形成した構造における減衰定数 α の変化を示す図。

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【図77】オイラー角 $(0^\circ, 140^\circ, 0^\circ)$ の $LiTaO_3$ 基板上に、様々な厚みの SiO_2 膜及び様々な厚みの白金からなるIDTを形成した構造における減衰定数 α の変化を示す図。

【図78】オイラー角 $(0^\circ, \theta, 0^\circ)$ の $LiTaO_3$ 基板上に、様々な厚みの白金よりなる電極膜を形成し、さらに規格化膜厚 $HS/\lambda = 0.1$ の SiO_2 膜を形成した弾性表面波装置における θ と、白金よりなる電極膜の規格化厚み H/λ と、減衰定数 α との関係を示す図。

【図79】オイラー角 $(0^\circ, \theta, 0^\circ)$ の $LiTaO_3$ 基板上に、様々な厚みの白金よりなる電極膜を形成し、さらに規格化膜厚 $HS/\lambda = 0.15$ の SiO_2 膜を形成した弾性表面波装置における θ と、白金よりなる電極膜の規格化厚み H/λ と、減衰定数 α との関係を示す図。

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【図80】オイラー角 $(0^\circ, \theta, 0^\circ)$ の $LiTaO_3$ 基板上に、様々な厚みの白金よりなる電極膜を形成し、さらに規格化膜厚 $HS/\lambda = 0.2$ の SiO_2 膜を形成した弾性表面波装置における θ と、白金よりなる電極膜の規格化厚み H/λ と、減衰定数 α との関係を示す図。

【図81】オイラー角 $(0^\circ, \theta, 0^\circ)$ の $LiTaO_3$ 基板上に、様々な厚みの白金よりなる電極膜を形成し、さらに規格化膜厚 $HS/\lambda = 0.25$ の SiO_2 膜を形成した弾性表面波装置における θ と、白金よりなる電極膜の規格化厚み H/λ と、減衰定数 α との関係を示す図。

【図82】オイラー角 $(0^\circ, \theta, 0^\circ)$ の $LiTaO_3$ 基板上に、様々な厚みの白金よりなる電極膜を形成し、さらに規格化膜厚 $HS/\lambda = 0.3$ の SiO_2 膜を形成した弾性表面波装置における θ と、白金よりなる電極膜の規格化厚み H/λ と、減衰定数 α との関係を示す図。

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【図83】オイラー角 $(0^\circ, \theta, 0^\circ)$ の $LiTaO_3$ 基板上に、様々な厚みの白金よりなる電極膜を形成し、さらに規格化膜厚 $HS/\lambda = 0.4$ の SiO_2 膜を形成した弾性表面波装置における θ と、白金よりなる電極膜の規格化厚み H/λ と、減衰定数 α との関係を示す図。

【図84】オイラー角 $(0^\circ, 126^\circ, 0^\circ)$ の $LiTaO_3$ 基板上に白金からなるIDTを形成し、さらに SiO_2 膜を形成した場合の白金膜の膜厚と、 SiO_2 膜の膜厚と、音速との関係を示す図。

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【図 85】オイラー角 (0° , 126° , 0°) の LiTaO_3 基板上に白金からなる IDT を形成し、さらに SiO_2 膜を形成した場合の白金膜の膜厚と、 SiO_2 膜の膜厚と、音速との関係を示す図。

【図 86】オイラー角 (0° , 120° , 0°) の LiTaO_3 基板上に、様々な厚みの SiO_2 膜及び様々な厚みのニッケルからなる IDT を形成した構造における減衰定数 α の変化を示す図。

【図 87】オイラー角 (0° , 140° , 0°) の LiTaO_3 基板上に、様々な厚みの SiO_2 膜及び様々な厚みのニッケルからなる IDT を形成した構造における減衰定数 α の変化を示す図。

【図 88】オイラー角 (0° , 120° , 0°) の LiTaO_3 基板上に、様々な厚みの SiO_2 膜及び様々な厚みのモリブデンからなる IDT を形成した構造における減衰定数 α の変化を示す図。

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【図 89】オイラー角 (0° , 140° , 0°) の LiTaO_3 基板上に、様々な厚みの SiO_2 膜及び様々な厚みのモリブデンからなる IDT を形成した構造における減衰定数 α の変化を示す図。

【図 90】オイラー角 (0° , θ , 0°) の LiTaO_3 基板上に、様々な厚みのニッケルよりなる電極膜を形成し、さらに規格化膜厚 $HS/\lambda = 0.1$ の SiO_2 膜を形成した弾性表面波装置における θ と、ニッケルよりなる電極膜の規格化厚み H/λ と、減衰定数 α との関係を示す図。

【図 91】オイラー角 (0° , θ , 0°) の LiTaO_3 基板上に、様々な厚みのニッケルよりなる電極膜を形成し、さらに規格化膜厚 $HS/\lambda = 0.2$ の SiO_2 膜を形成した弾性表面波装置における θ と、ニッケルよりなる電極膜の規格化厚み H/λ と、減衰定数 α との関係を示す図。

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【図 92】オイラー角 (0° , θ , 0°) の LiTaO_3 基板上に、様々な厚みのニッケルよりなる電極膜を形成し、さらに規格化膜厚 $HS/\lambda = 0.3$ の SiO_2 膜を形成した弾性表面波装置における θ と、ニッケルよりなる電極膜の規格化厚み H/λ と、減衰定数 α との関係を示す図。

【図 93】オイラー角 (0° , θ , 0°) の LiTaO_3 基板上に、様々な厚みのニッケルよりなる電極膜を形成し、さらに規格化膜厚 $HS/\lambda = 0.4$ の SiO_2 膜を形成した弾性表面波装置における θ と、ニッケルよりなる電極膜の規格化厚み H/λ と、減衰定数 α との関係を示す図。

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【図 94】オイラー角 (0° , θ , 0°) の LiTaO_3 基板上に、様々な厚みのモリブデンよりなる電極膜を形成し、さらに規格化膜厚 $HS/\lambda = 0.1$ の SiO_2 膜を形成した弾性表面波装置における θ と、モリブデンよりなる電極膜の規格化厚み H/λ と、減衰定数 α との関係を示す図。

【図 95】オイラー角 (0° , θ , 0°) の LiTaO_3 基板上に、様々な厚みのモリブデンよりなる電極膜を形成し、さらに規格化膜厚 $HS/\lambda = 0.2$ の SiO_2 膜を形成した弾性表面波装置における θ と、モリブデンよりなる電極膜の規格化厚み H/λ と、減衰定数 α との関係を示す図。

【図 96】オイラー角 (0° , θ , 0°) の LiTaO_3 基板上に、様々な厚みのモリブデンよりなる電極膜を形成し、さらに規格化膜厚 $HS/\lambda = 0.3$ の SiO_2 膜を形成した弾性表面波装置における θ と、モリブデンよりなる電極膜の規格化厚み H/λ と、減衰定数 α との関係を示す図。

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【図 97】オイラー角 (0° , θ , 0°) の LiTaO_3 基板上に、様々な厚みのモリブデンよりなる電極膜を形成し、さらに規格化膜厚 $HS/\lambda = 0.4$ の SiO_2 膜を形成した弾性表面波装置における θ と、モリブデンよりなる電極膜の規格化厚み H/λ と、減衰定数 α との関係を示す図。

【図 98】オイラー角 (0° , 126° , 0°) の LiTaO_3 基板上にニッケルからなる IDT が形成されており、さらに様々な厚みの SiO_2 膜が形成された場合のニッケル膜の膜厚と、ニッケル膜の膜厚と、音速との関係を示す図。

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【図 99】オイラー角 (0° , 126° , 0°) の LiTaO_3 基板上に、様々な膜厚のニッケルからなる IDT が形成されており、その上に SiO_2 膜が形成されている構造における、 SiO_2 膜の膜厚と、音速との関係を示す図。

【図 100】オイラー角 (0° , 126° , 0°) の LiTaO_3 基板上にモリブデンからなる IDT が形成されており、その上に様々な膜厚の SiO_2 膜が形成された場合構造におけるモリブデンの規格化膜厚と、音速との関係を示す図。

【図 101】オイラー角 (0° , 126° , 0°) の LiTaO_3 基板上に様々な膜厚のモリブデンからなる IDT を形成し、さらに SiO_2 膜を形成した構造における、 SiO_2 膜の規格化膜厚と、音速との関係を示す図。

【図 102】(a) ~ (c) は、絶縁物層表面の平坦化を図る方法の一例としてのエッチバック法を説明するための各模式的断面図。 10

【図 103】(a) ~ (d) は、絶縁物層表面を平坦化する方法の他の例としての逆スパッタ法を説明するための各模式的断面図。

【図 104】(a) 及び (b) は、絶縁物層表面を平坦化する方法のさらに他の例を示す模式的断面図である。

【図 105】(a) ~ (c) は、絶縁物層表面を平坦化するさらに別の方法を説明するための各模式的断面図。

【図 106】(a) 及び (b) は、本発明が適用される弾性表面波装置の一例としての 1 ポート型共振子及び 2 ポート型共振子を説明するための各模式的平面図。

【図 107】本発明が適用される弾性表面波装置としてのラダー型フィルタを説明するための模式的平面図。 20

【図 108】本発明が適用される弾性表面波装置としてのラチス型フィルタを説明するための模式的平面図。

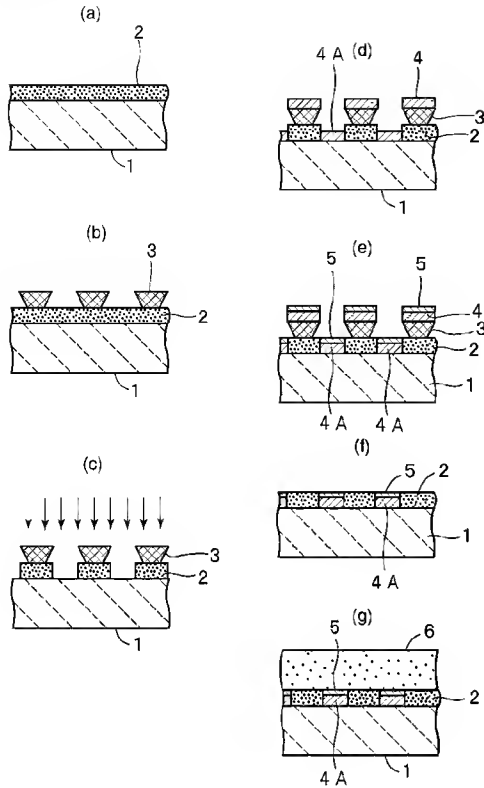
【図 109】(a) ~ (d) は、従来の弾性表面波装置の製造方法の一例を示すための模式的断面図。

【図 110】従来の弾性表面波装置の一例を説明するための模式的正面断面図。。

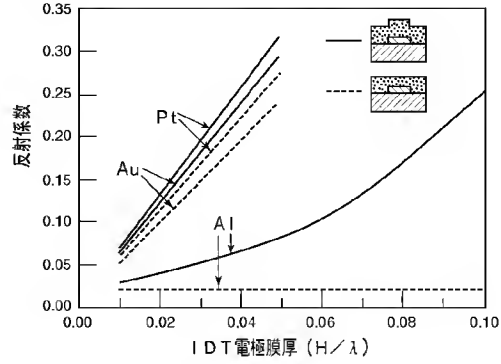
【符号の説明】

- 1 LiTaO_3 基板
- 2 第 1 絶縁物層
- 3 レジストパターン
- 4 金属膜
- 4A IDT 電極
- 5 保護金属膜としての Ti 膜
- 6 第 2 絶縁物層
- 11 弾性表面波共振子
- 12, 13 反射器
- 21 弾性表面波装置
- 22 LiTaO_3 基板
- 23a, 23b IDT
- 25 SiO_2 膜

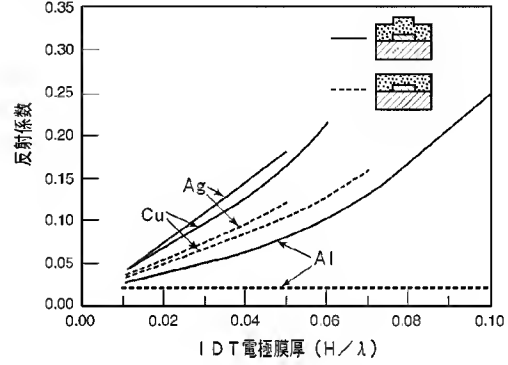
【図 1】



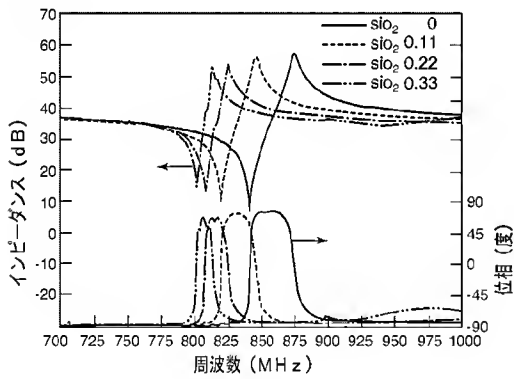
【図 2】



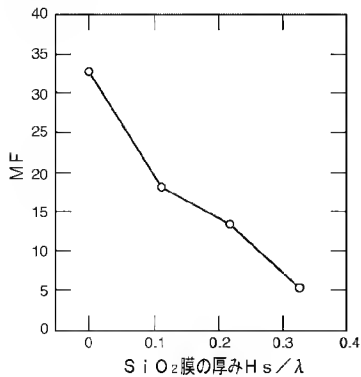
【図 3】



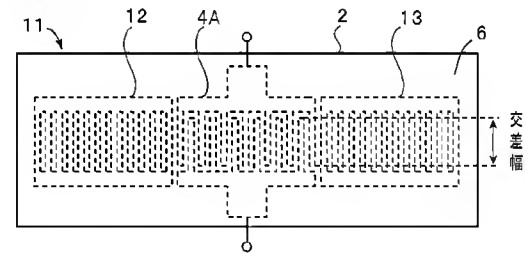
【図 4】



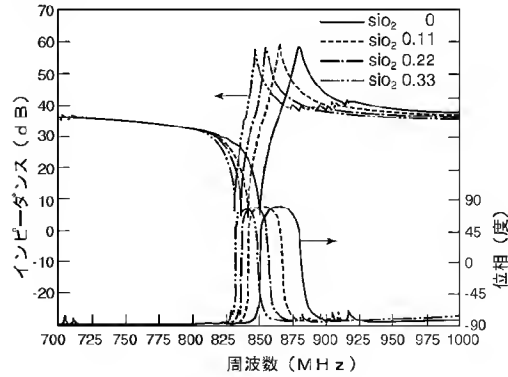
【図 5】



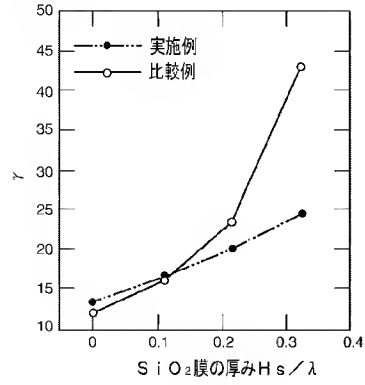
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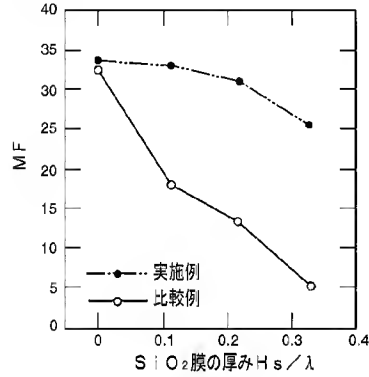
【図 7】



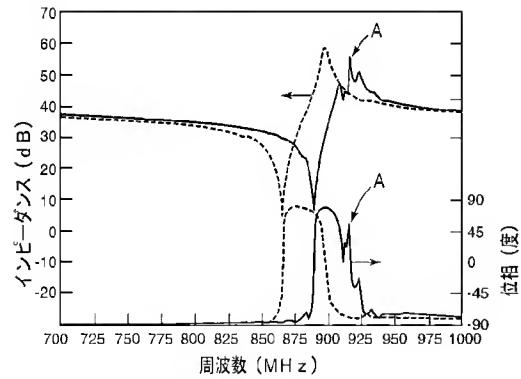
【図 8】



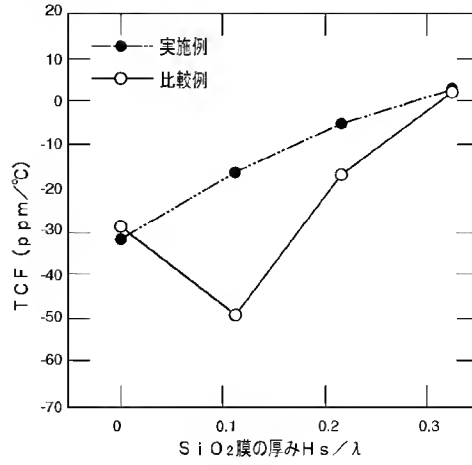
【図 9】



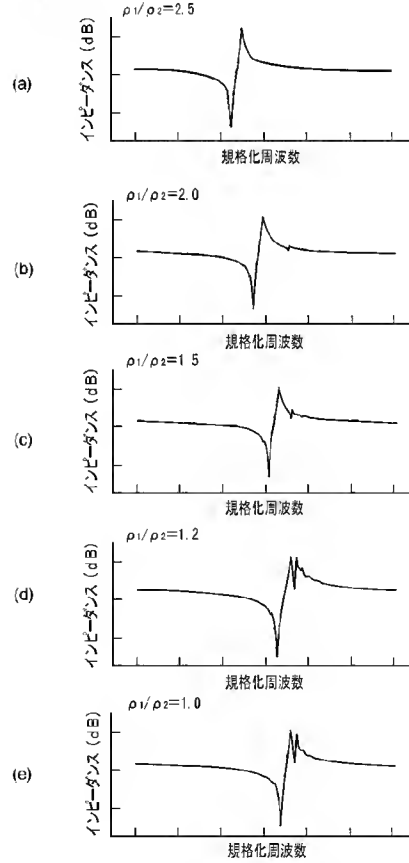
【図 11】



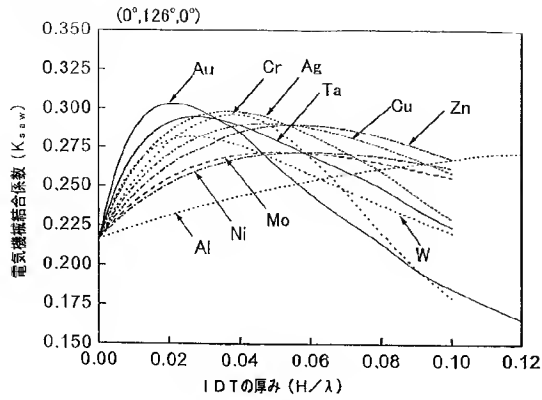
【図 10】



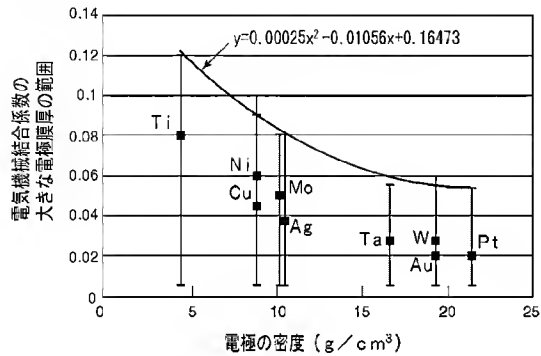
【図 12】



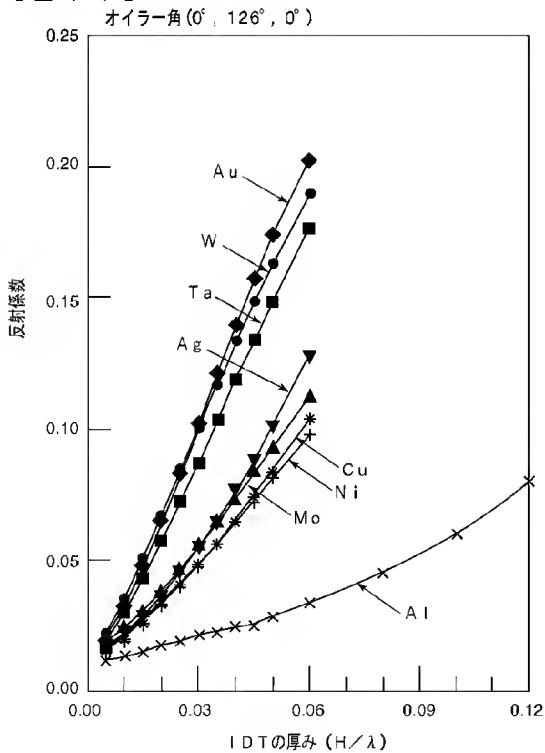
【図 13】



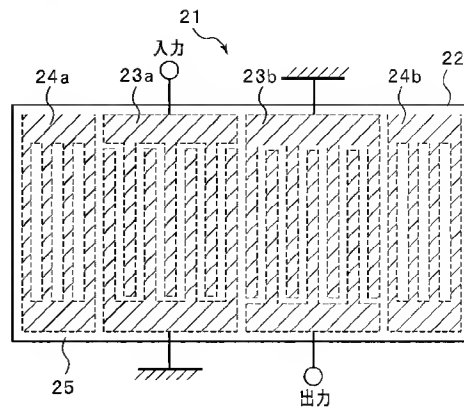
【図 14】



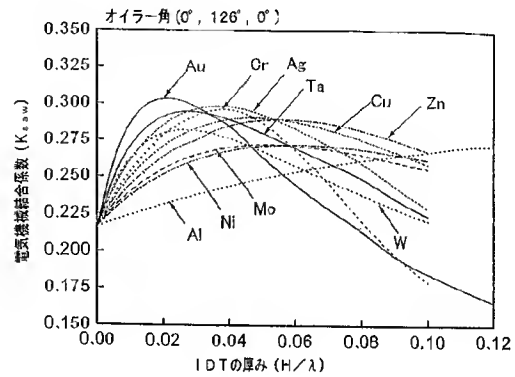
【図 17】



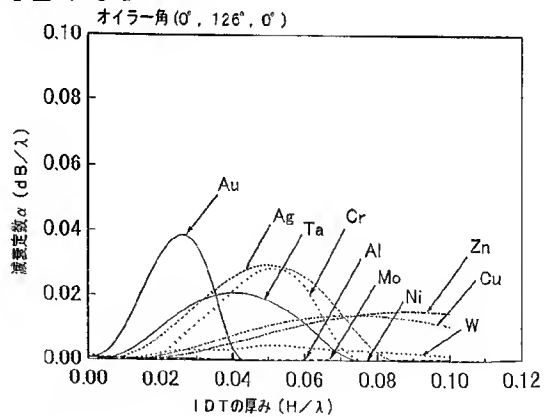
【図 15】



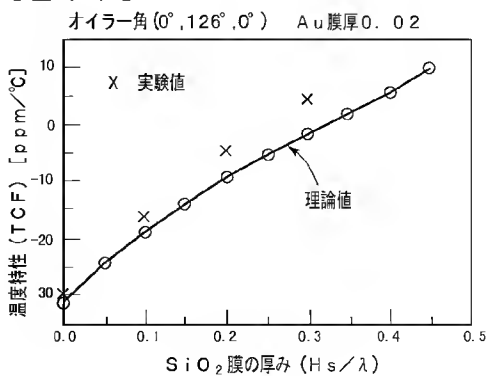
【図 16】



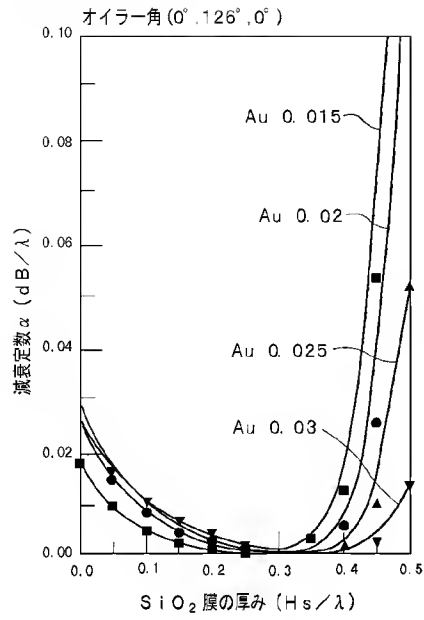
【図 18】



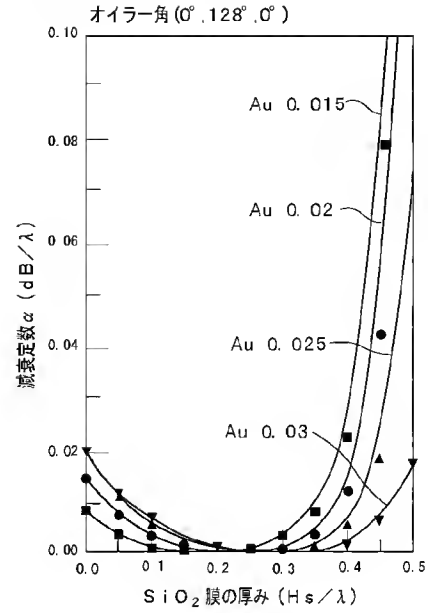
【図 19】



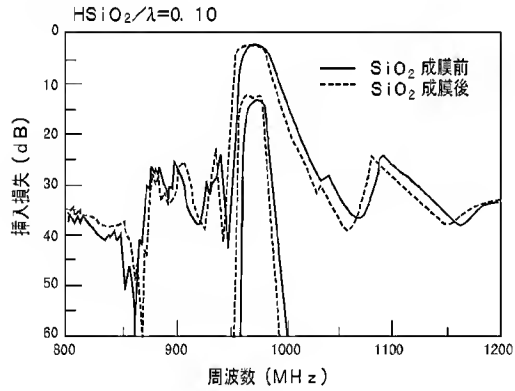
【図 20】



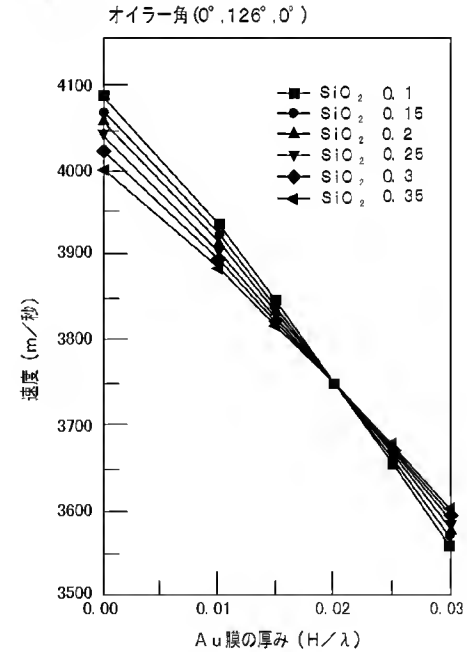
【図 21】



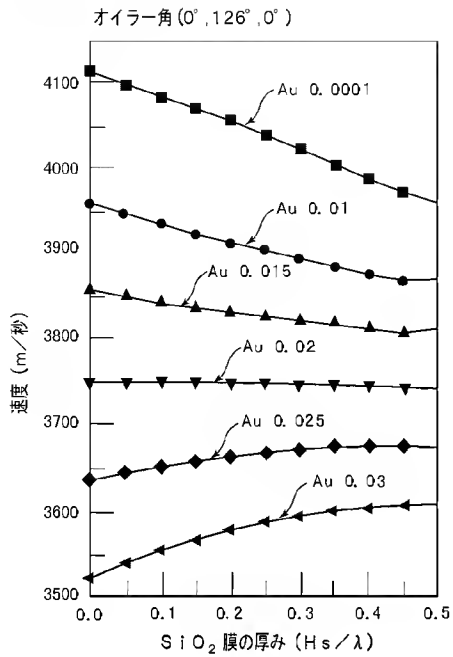
【図 22】



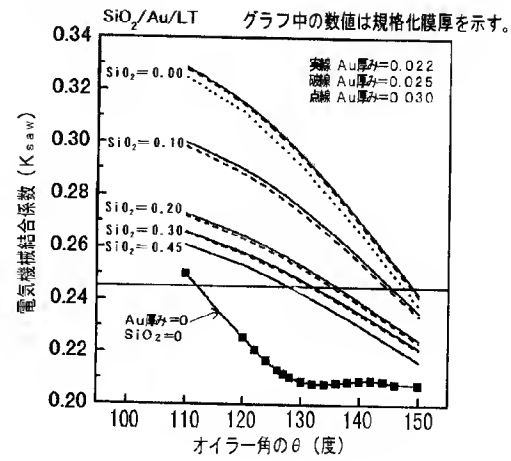
【図 23】



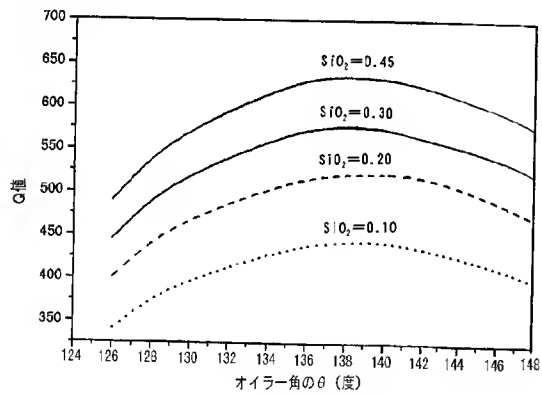
【図 24】



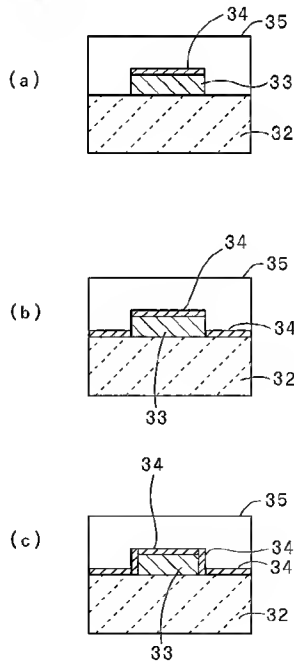
【図 25】



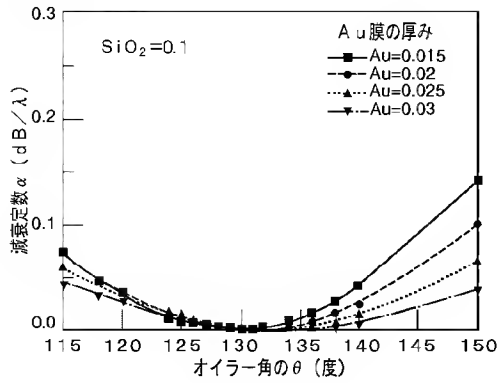
【図 26】



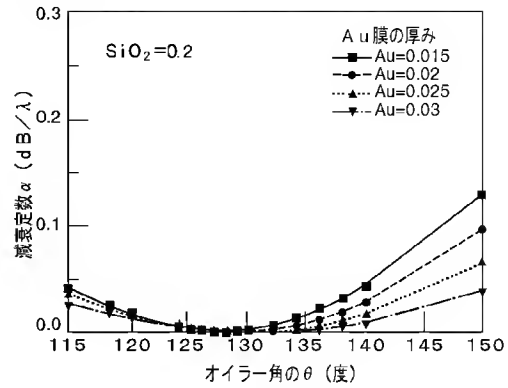
【図 27】



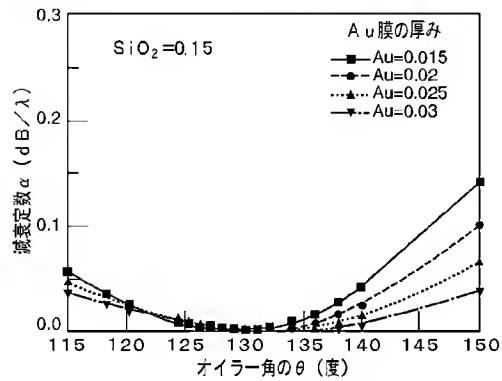
【図 28】



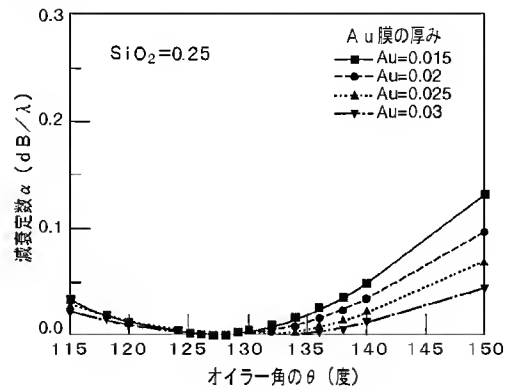
【図 30】



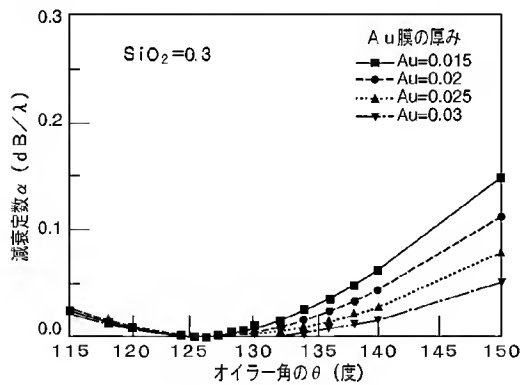
【図 29】



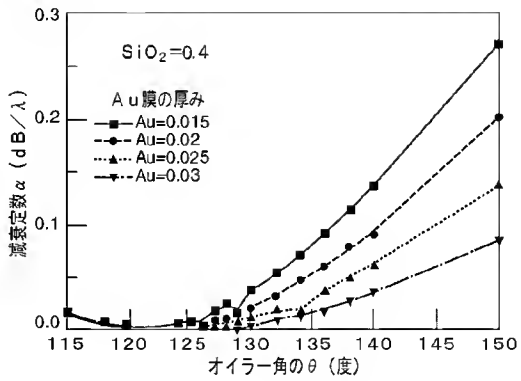
【図 31】



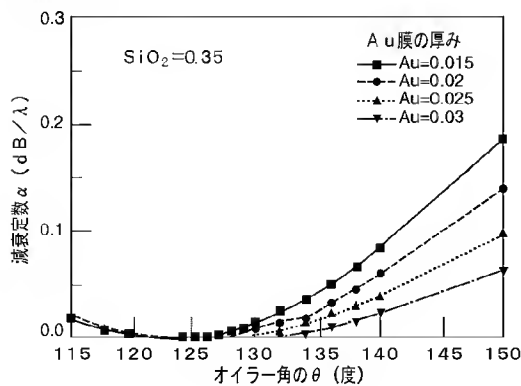
【図 32】



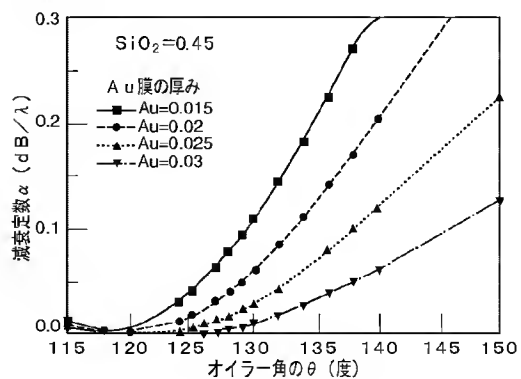
【図 34】



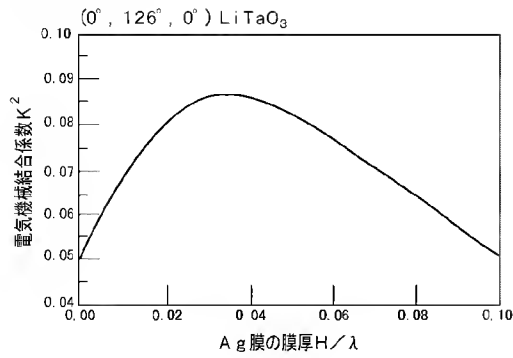
【図 33】



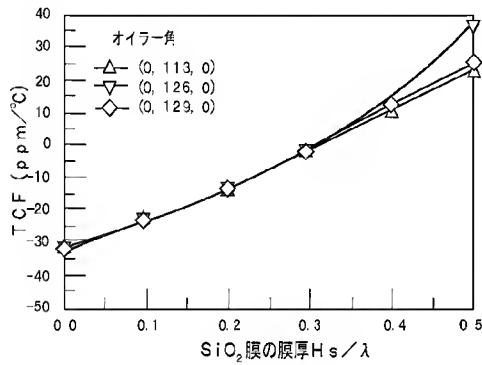
【図 35】



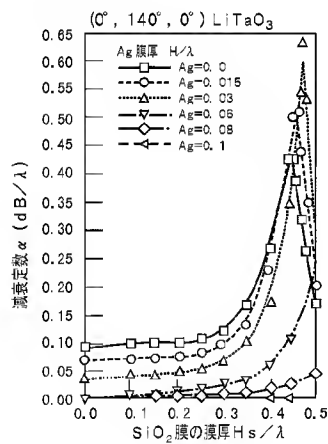
【図 36】



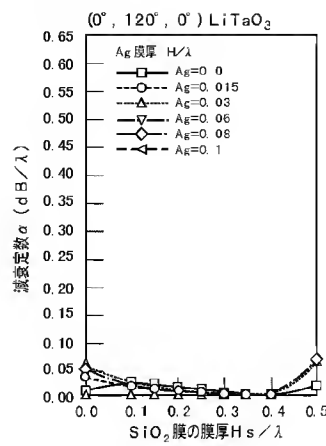
【図 37】



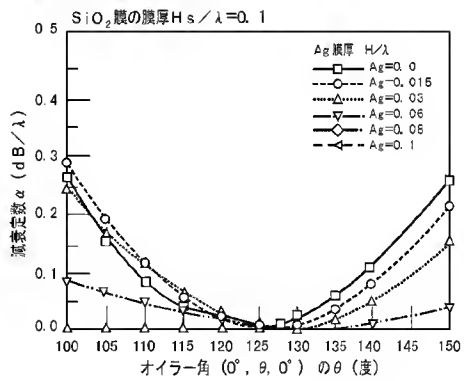
【図 39】



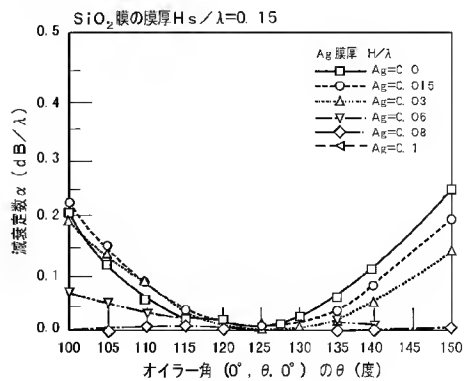
【図 38】



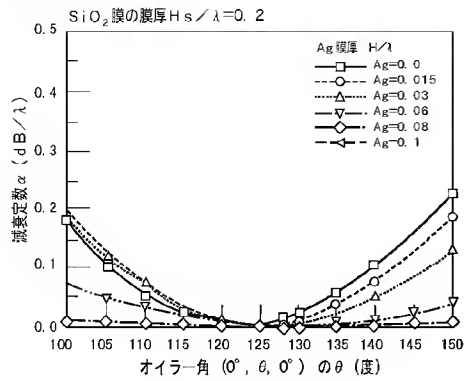
【図 40】



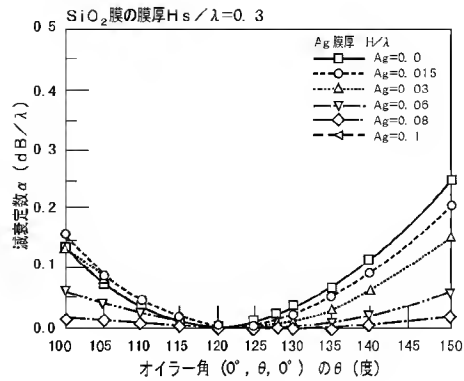
【図 41】



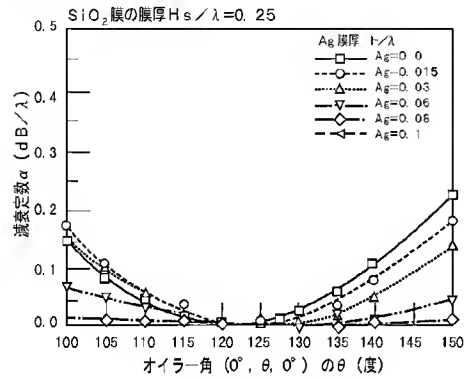
【図 4 2】



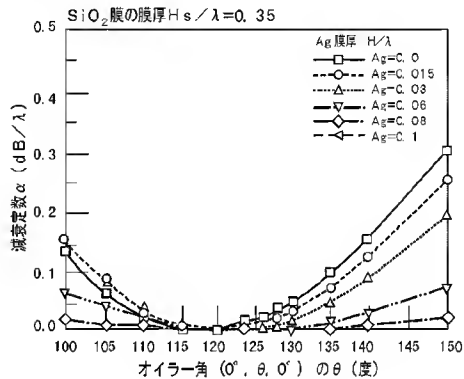
【図 4 4】



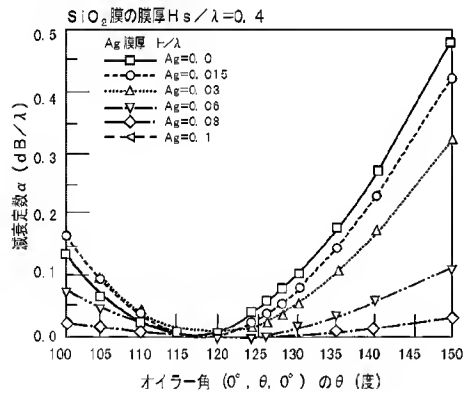
【図 4 3】



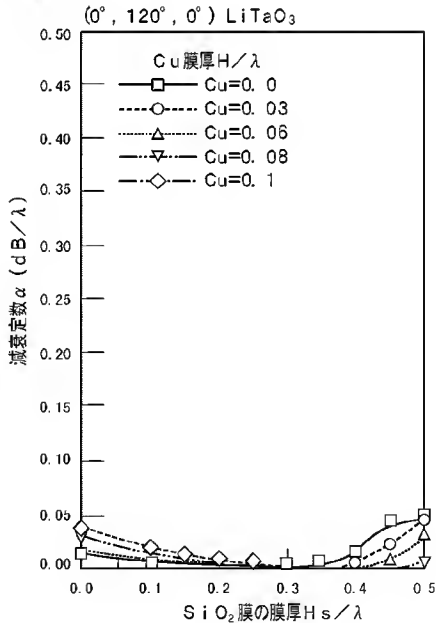
【図 4 5】



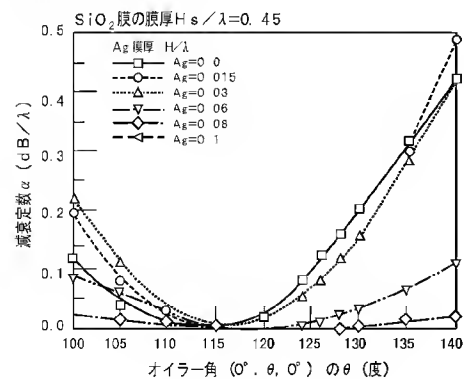
【図 4 6】



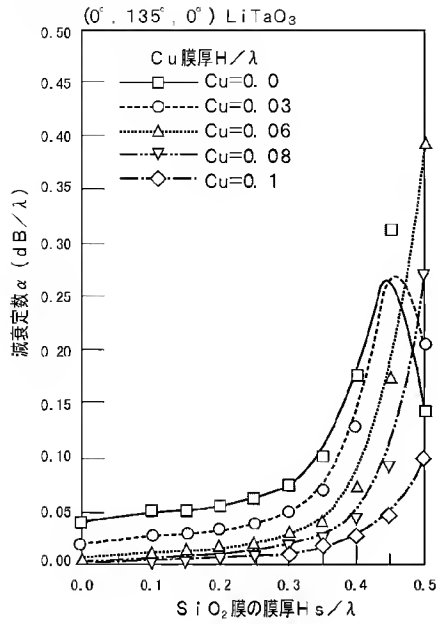
【図 4 8】



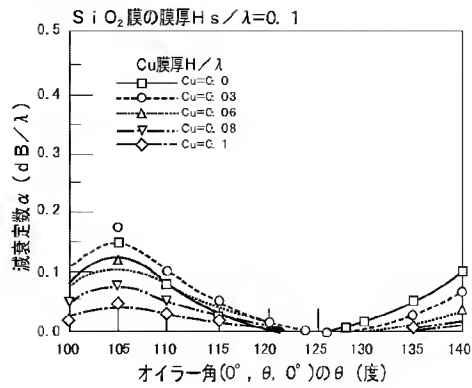
【図 4 7】



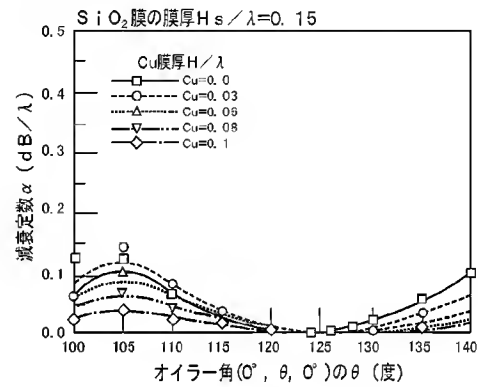
【図 49】



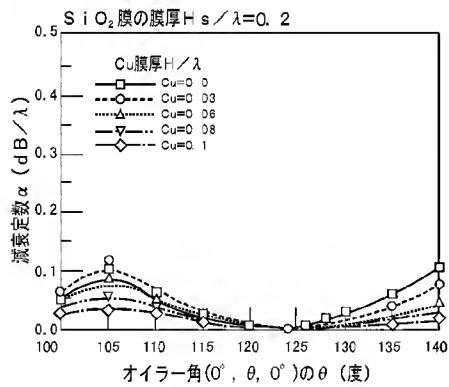
【図 50】



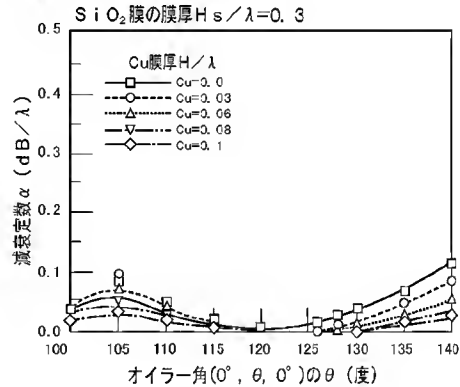
【図 51】



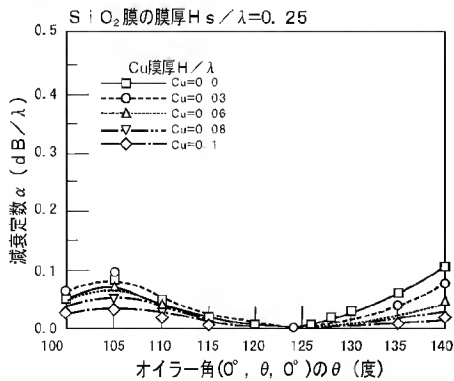
【図 52】



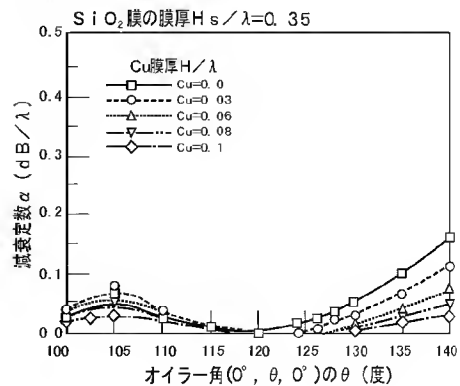
【図 54】



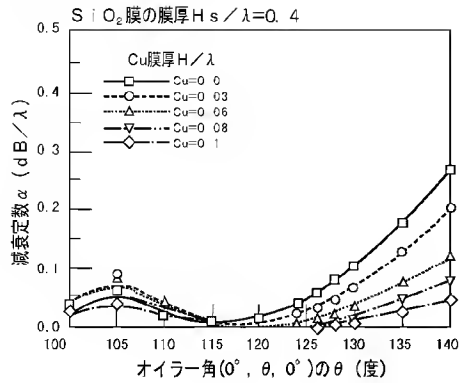
【図 53】



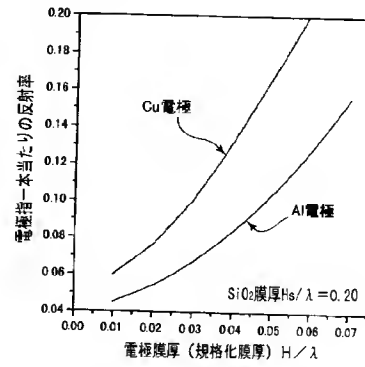
【図 55】



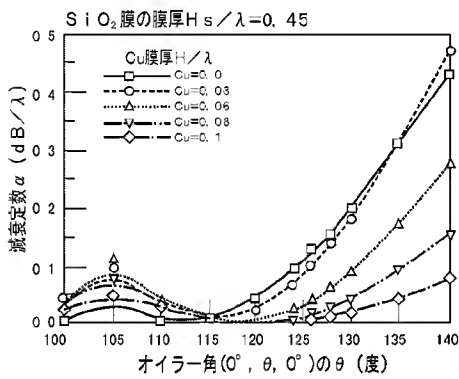
【図 56】



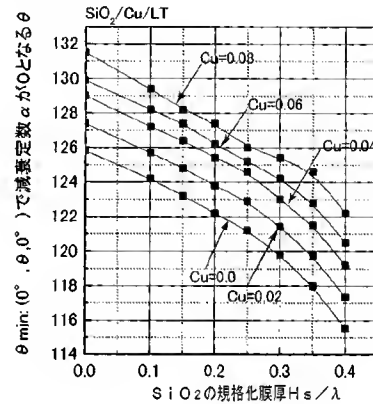
【図 58】



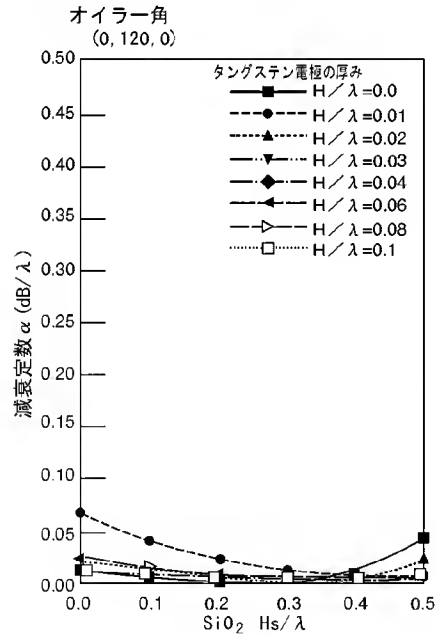
【図 57】



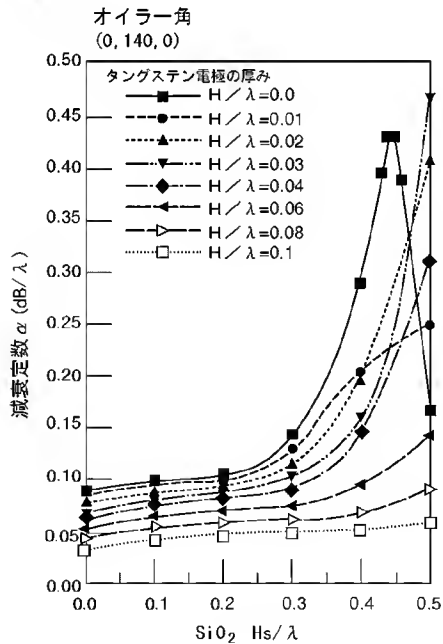
【図 59】



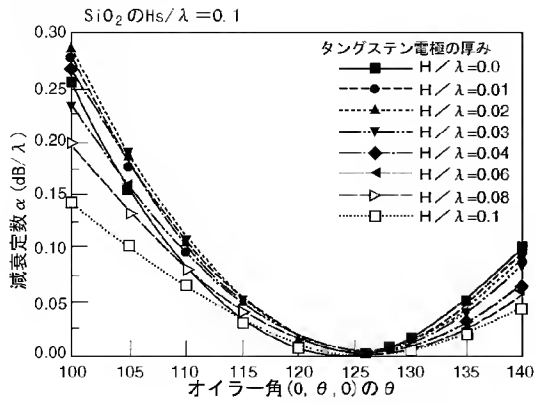
【図 60】



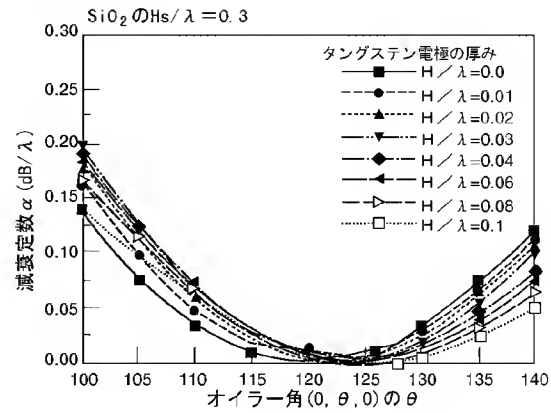
【図 61】



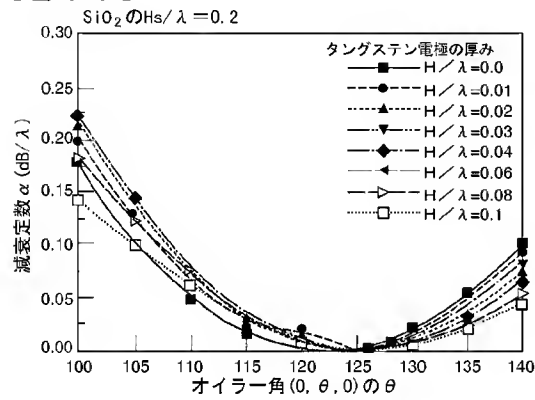
【図 6 2】



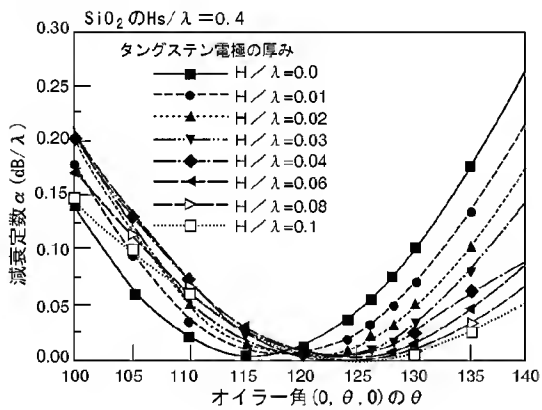
【図 6 4】



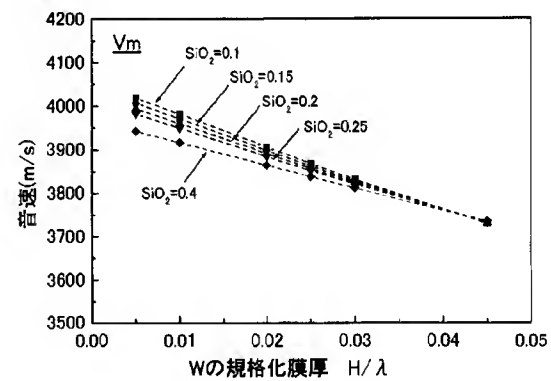
【図 6 3】



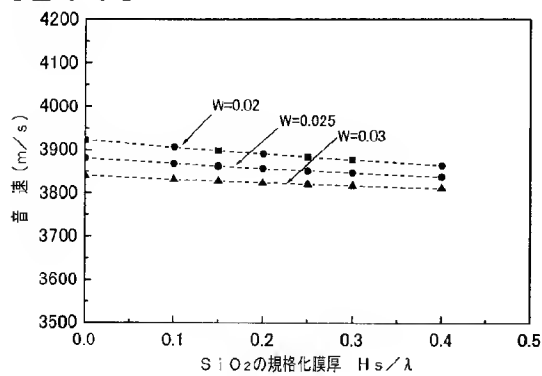
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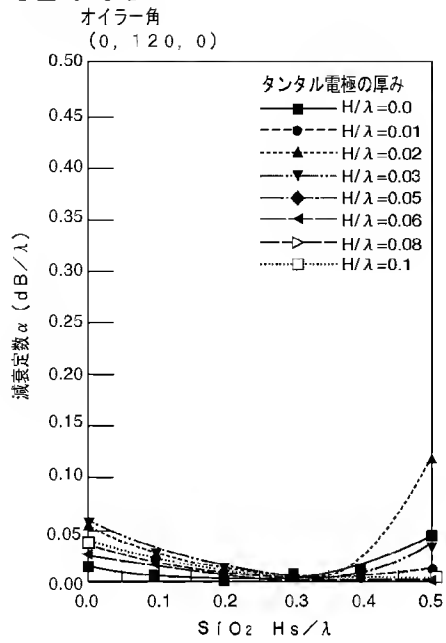
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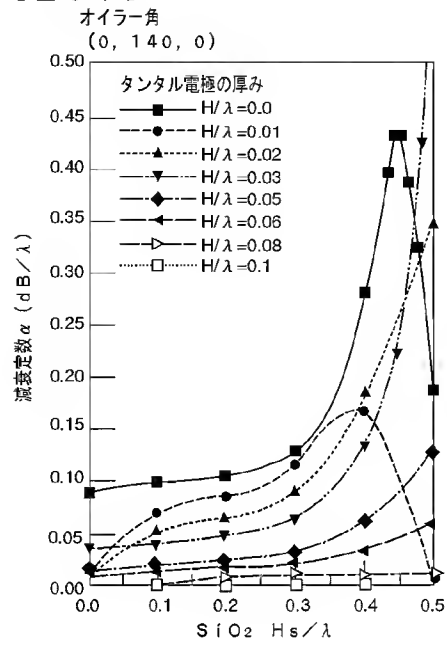
【図 6 6】



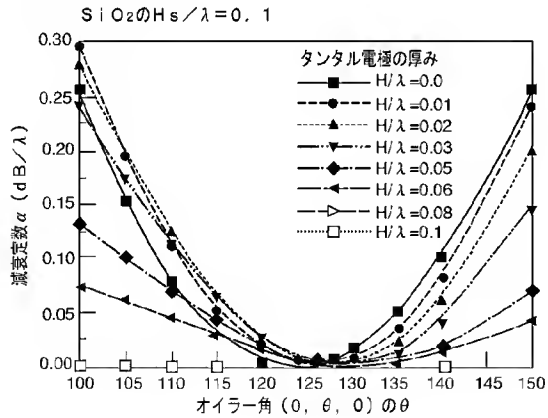
【図 68】



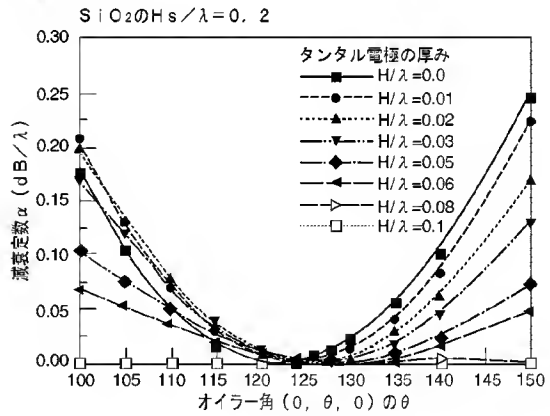
【図 69】



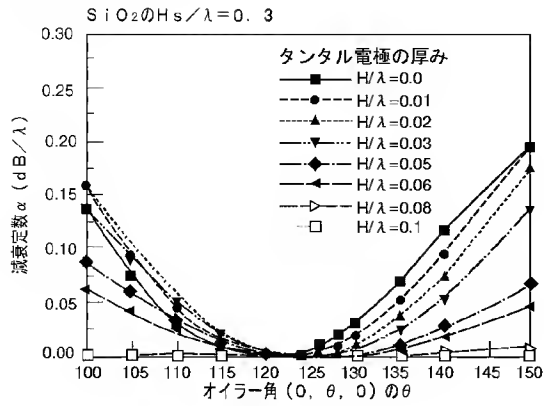
【図 70】



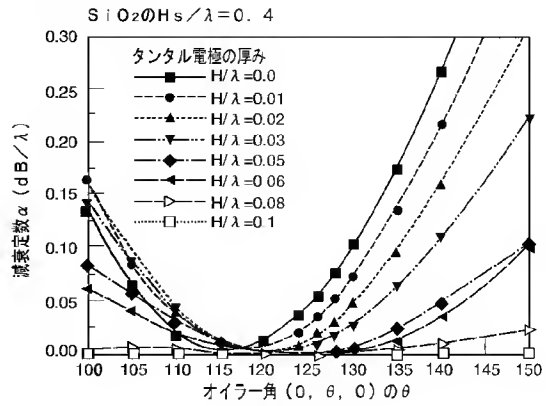
【図 71】



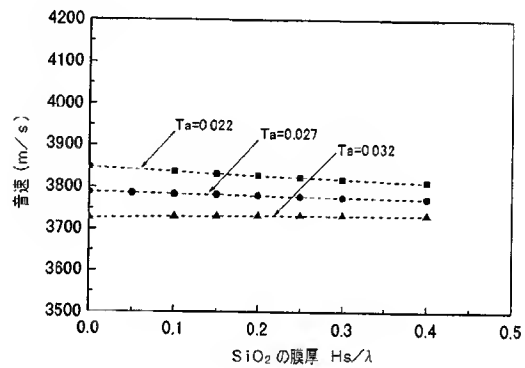
【図 7 2】



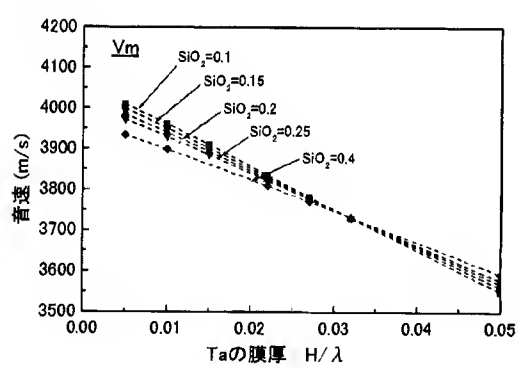
【図 7 3】



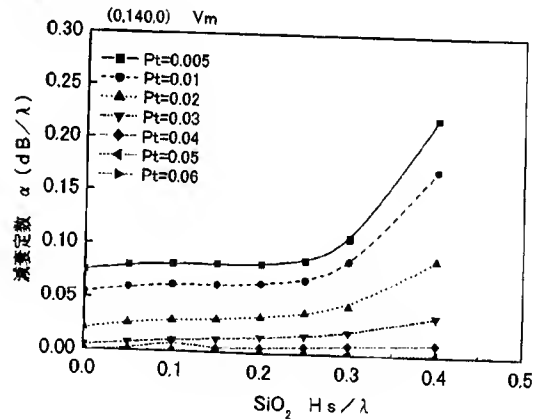
【図 7 4】



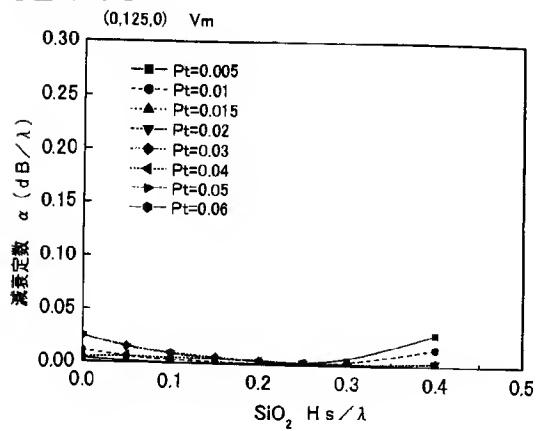
【図 7 5】



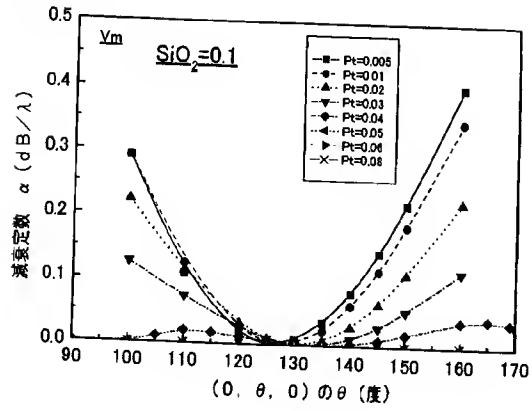
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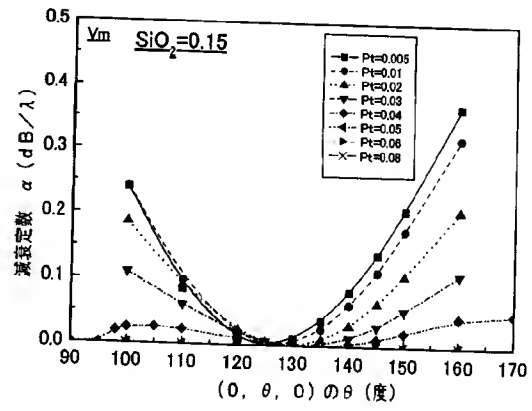
【図 7 6】



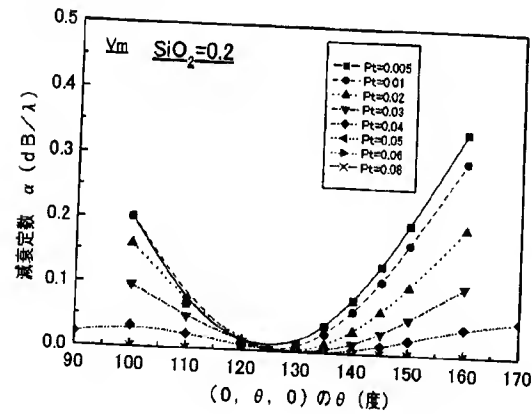
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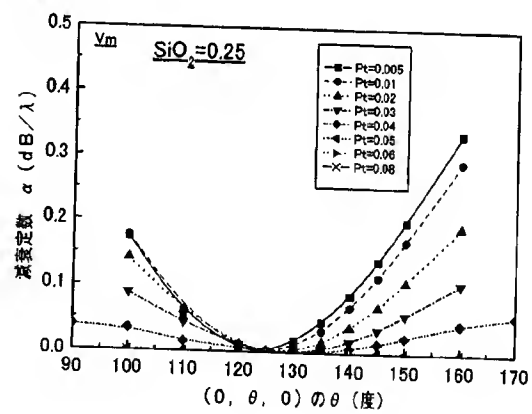
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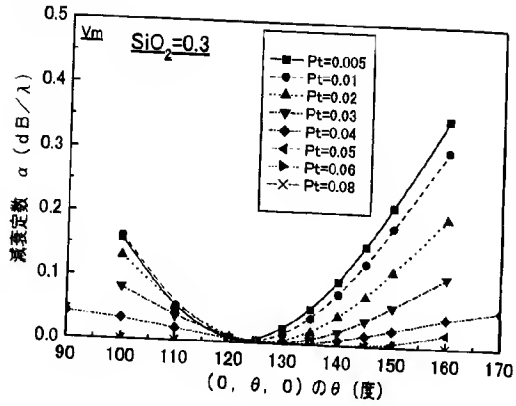
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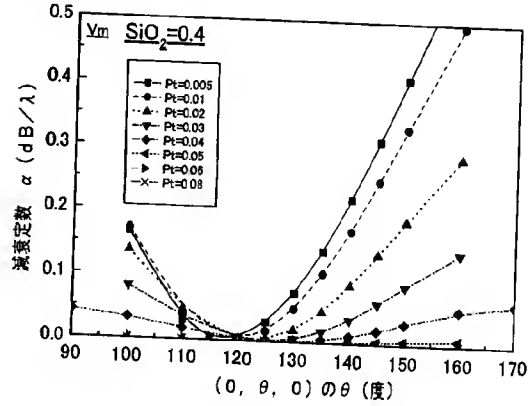
【図 81】



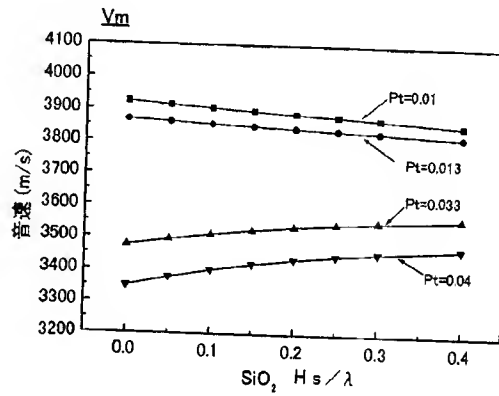
【図 8 2】



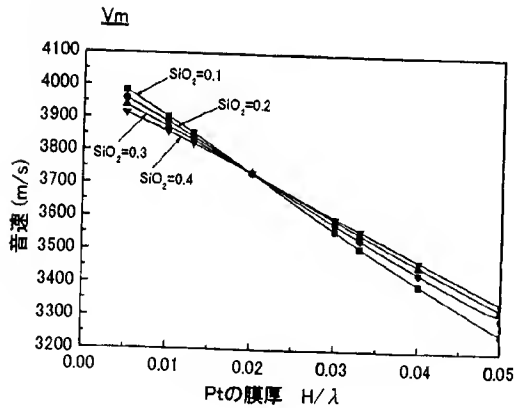
【図 8 3】



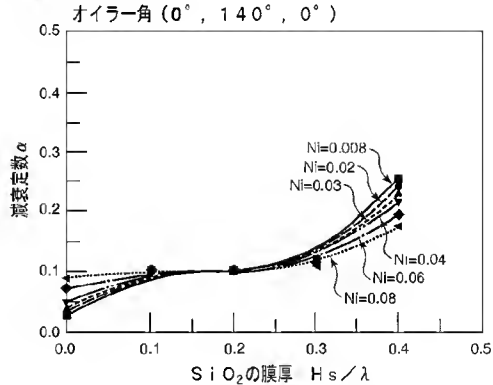
【図 8 4】



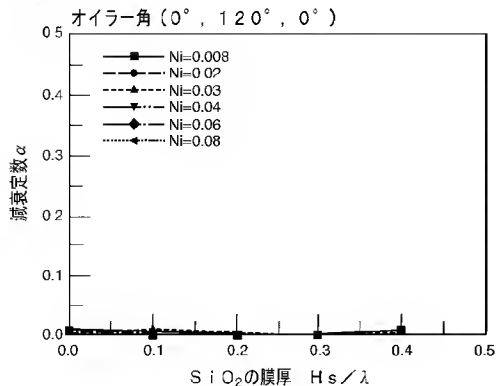
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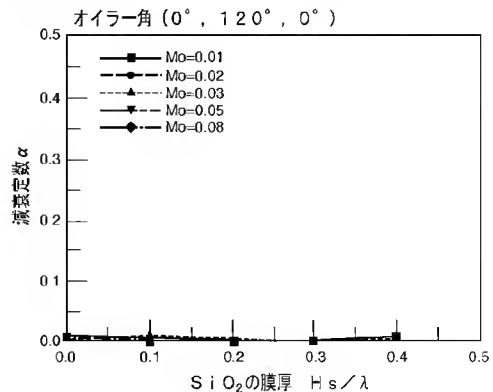
【図 8 7】



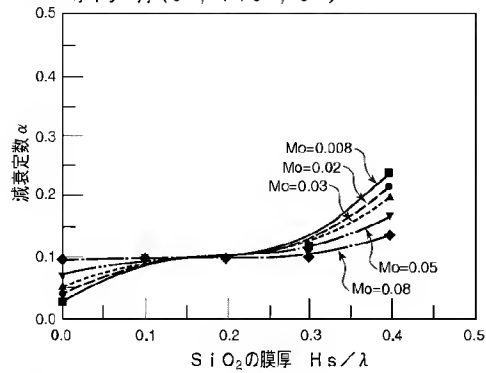
【図 8 6】



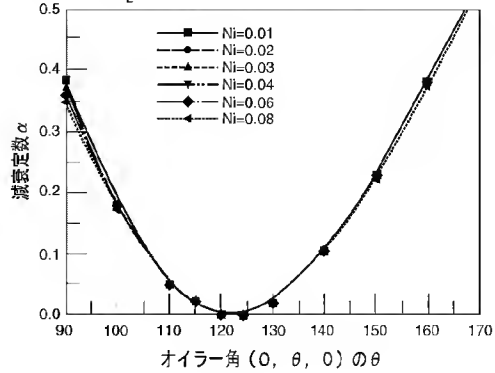
【図 8 8】



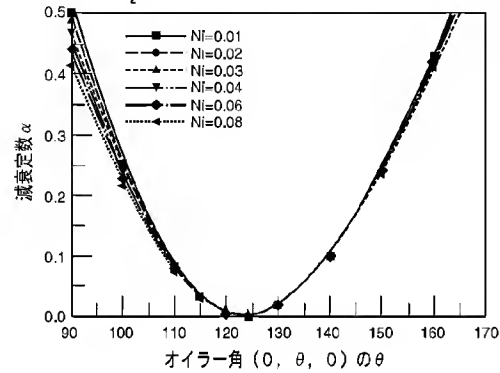
【図 89】

オイラー角 (0° , 140° , 0°)

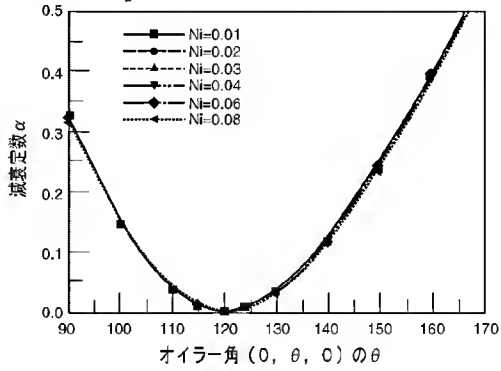
【図 91】

 $\text{SiO}_2=0.2$ 

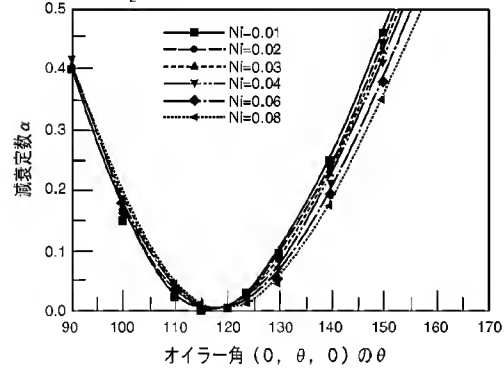
【図 90】

 $\text{SiO}_2=0.1$ 

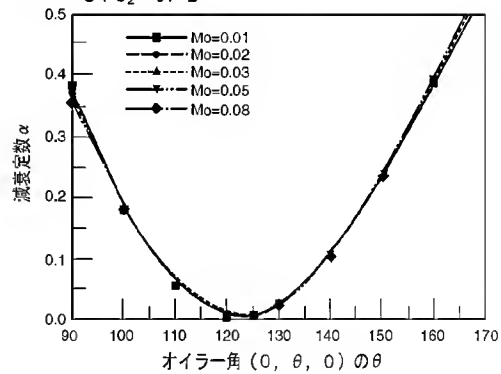
【図 92】

 $\text{SiO}_2=0.3$ 

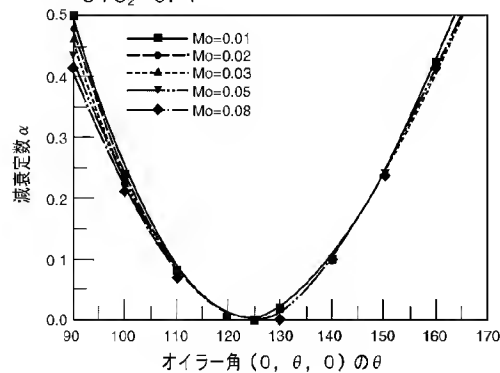
【図 93】

 $\text{SiO}_2=0.4$ 

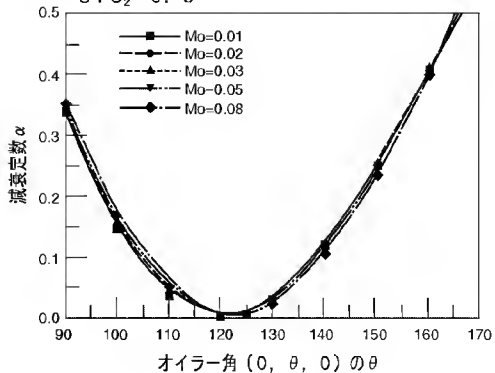
【図 95】

 $\text{SiO}_2=0.2$ 

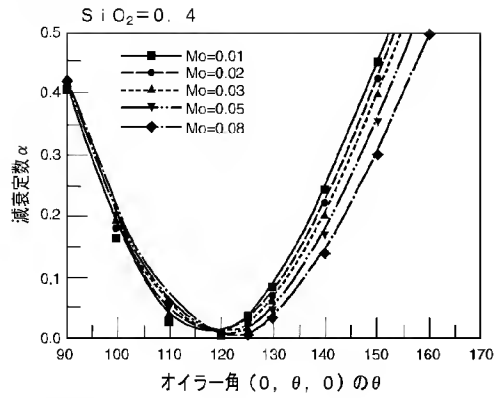
【図 94】

 $\text{SiO}_2=0.1$ 

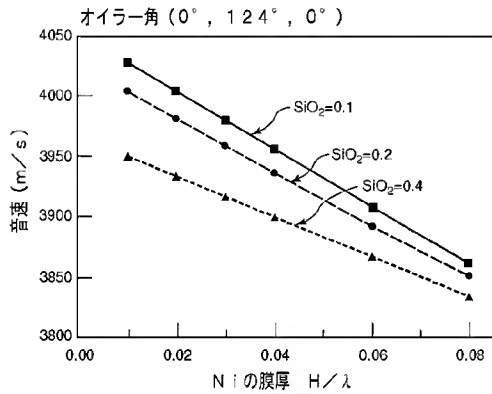
【図 96】

 $\text{SiO}_2=0.3$ 

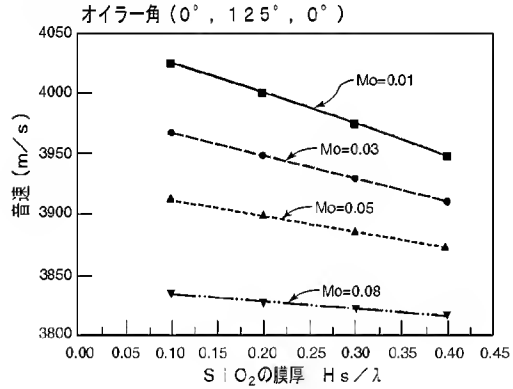
【図 97】



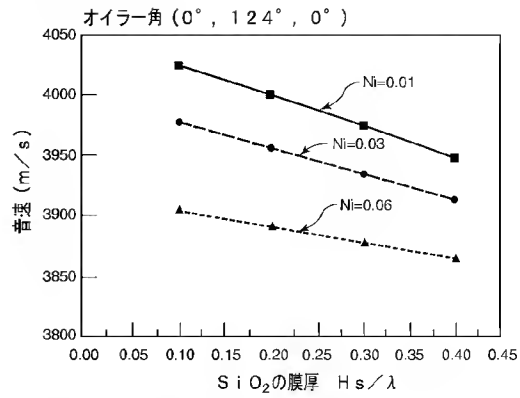
【図 98】



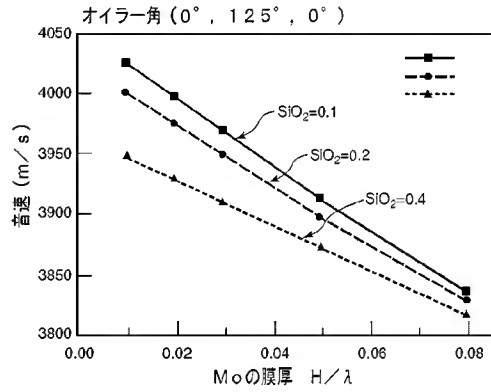
【図 101】



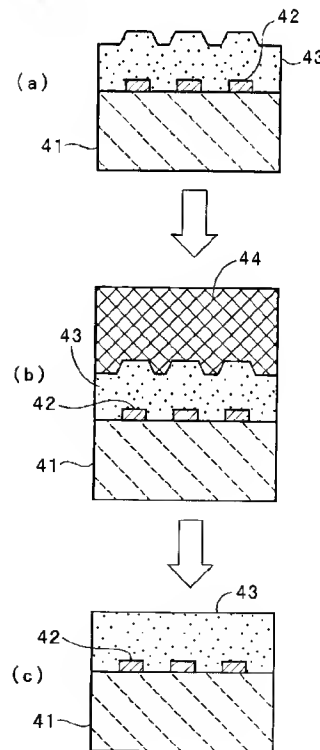
【図 99】



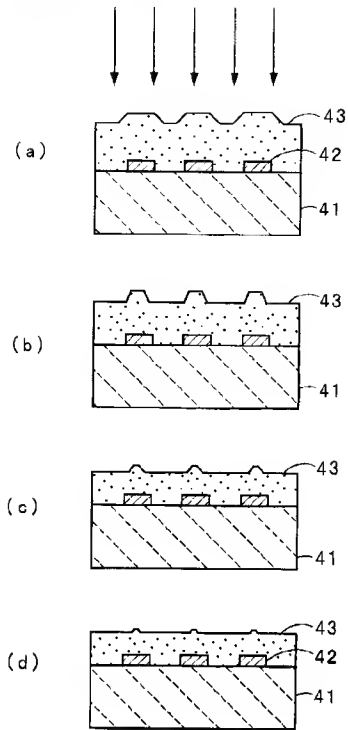
【図 100】



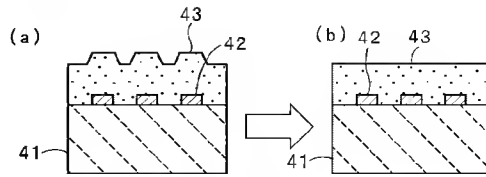
【図 102】



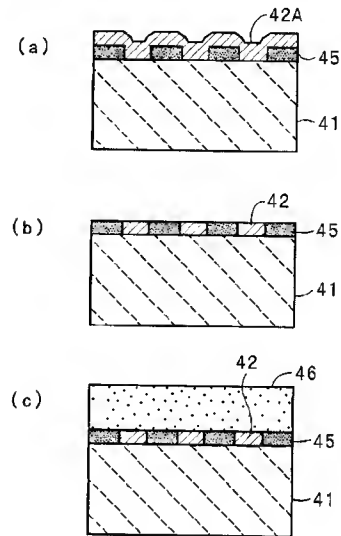
【図 103】



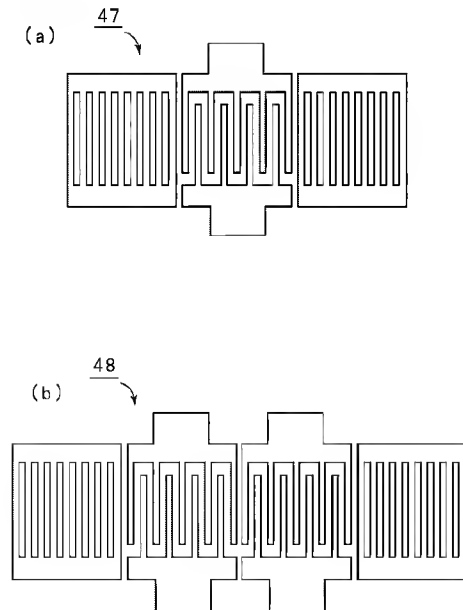
【図 104】



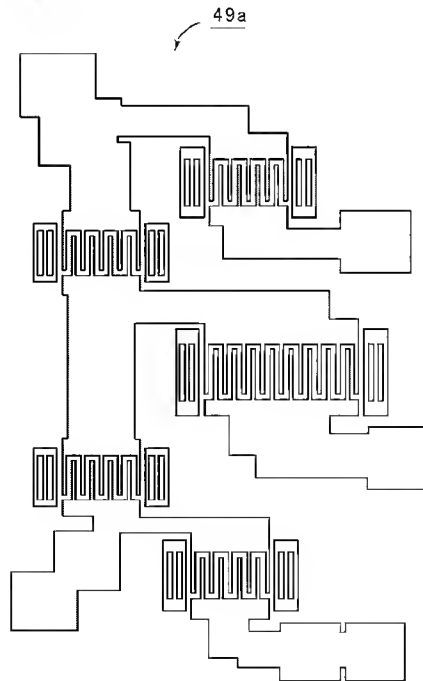
【図 105】



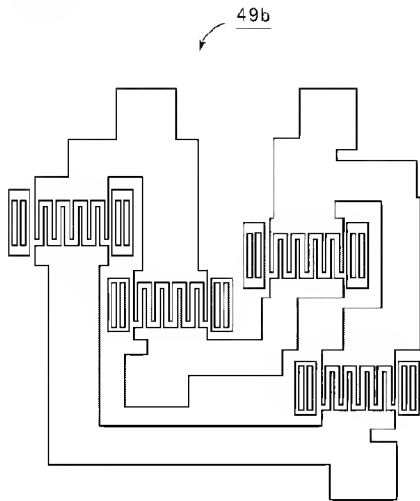
【図 106】



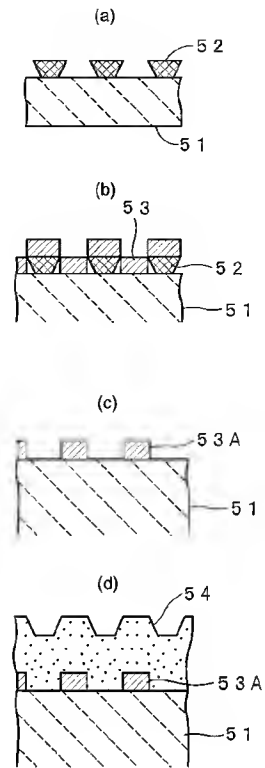
【図 107】



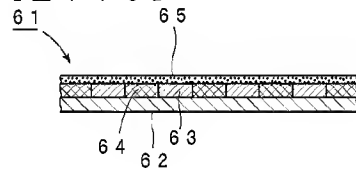
【図 108】



【図 109】



【図 110】



フロントページの続き

Fターム(参考) 5J097 AA13 AA15 AA24 BB01 DD28 DD29 EE10 FF03 FF05 GG03
GG07 HA02 HA03 KK04 KK05 KK09